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CONTENTS FOR JUNE 1940

Volume 21, Number 6

Hay Pitching Costs

HAY is one of several materials of low value per unit of weight or bulk handled in quantity on farms. It must be handled at correspondingly low cost or the possible economic advantage of handling it at all is easily lost. High cost and limitations of human muscular energy suggest the desirability of eliminating manual operations as far as possible in the handling of such materials. There is room for improvement wherever a pitchfork is still used. For small farms, choppers and blowers, with semi-automatic feed from stock piles of hay rolled or dumped off wagons or trucks, may be a part of the answer.

AGRICULTURAL ENGINEERING

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War Bread

WILL bombs and bullets, or famine, cause most human suffering in Europe in consequence of its current war? Its spring planting time has come and gone, and there are reports of serious interference with usual food production work. It is obvious that this is possible and entirely probable.

After two decades of thinking in terms of surpluses it is a little difficult to adjust our thinking to food shortage problems, but they are imminent.

There will probably be a major humanitarian problem of food supply, if and when conditions are such that food can be delivered to the people needing it. The governments and peoples concerned will be poverty stricken. Some will have credit in the United States and some will not. Some may need help through long periods of chaos and reconstruction.

As a creditor nation with more man power, manufacturing capacity, farm production capacity, and impounded gold than it knows how to use, this country can be paid for the farm products and other goods it might furnish, only in the raw materials it needs and does not have abundantly. Imports of goods that would keep American workers idle and not conserve important natural resources would be no payment at all.

What we have said previously about the improbability of American farmers profiting from the war[1], and about the adjustments it may require of our agriculture[2], still seem likely to prove true.

For the present, our program of building and showing a strong national defense, and an apparently growing interest in defending certain ideals of human right and principle wherever they may be attacked, requires a forward look to the possibilities of increasing our farm production with reduced man power, if necessary, and of avoiding some of the mistakes made by farmers during and following the war of 1914-18.

Factors in Farming Effectively

LAST month we invited attention to increasing farm operating efficiency as the one and only way of increasing, to any important extent, the economic service rendered by farmers and their resulting material prosperity[3].

An increase in farm capacity to render economic service has been one effect, if not always the direct objective, of much of the work of agriculture's public service agencies; of the improved equipment, materials, and methods made available to agriculture by commercial interests; and of the originality, experimenting, and management efforts of successful farmers. It has been partially obscured by loss of foreign markets, deflation of land and commodity prices, desire for larger cash income, drought, floods, and other misfortunes and readjustments, but it shows up in the increasing industrialization of this country, the decreasing proportion of farmers required to feed the total population, in decreased man-hours of farm work per bushel or ton of product; and in increased conveniences and luxuries enjoyed by farmers.

Without denying or belittling this progress, our point is that still more might be done to help farmers render more economic service and enjoy more prosperity if more concerted interest and effort were devoted to this objective, particularly by agricultural engineers. This is suggested by the extent to which environment influences yield and quality of farm products; the substantial proportion of farm work time and operating cost devoted to manipulating and controlling biological environment and to handling materials; and the fact that practical application of physical and chemical science in structural, mechanical, and electrical devices for improving human effectiveness in production and other activities is particularly the field of the engineer.

In other words, production or industrial engineering is an important phase of managing the production of commodities. Corresponding principles, data, and techniques might be developed and applied by agricultural engineers as an aid to and one phase of farm management, and with the specific objective of helping farmers work more effectively.

Physical elements in farm operating efficiency include (1) the efficiency of the individual act, equipment unit, or operation; (2) the coordination of individual operations and production facilities for high overall efficiency and capacity to farm intensively or extensively; and (3) the economic justification of operations, manipulations, and controls by reason of the environment provided for biological functions and the influence of such environment on yield, quality, and value of farm production.

Considerable has already been done to improve the efficiency of individual farm operations and machines. Animal and mechanical power have been substituted for man power in many instances. Machines have been designed to do work formerly done by hand, and to do it faster and better. And these machines have been consistently improved. There is room for further improvement.

Farm jobs are susceptible to such production engineering techniques as operation analysis, and time and motion study. There are best ways of doing manual labor and of operating machines. They offer opportunity for farmers to improve work effectiveness at little or no cost. Whether or not a farmer's operations represent current best practice, and whether or not current best practices will be supported by new scientific knowledge, lowering their cost and increasing their effectiveness is important to the extent that they are and will continue to be practiced.

Coordination of individual operations and production facilities implies balancing of capacity to handle the work to be done at all stages of production and all times of the year, with a minimum of alternate work peaks and idle periods. It implies building, barnyard, and field layout to minimize lost motion and waste of materials between operations. It implies balancing of engineering with other factors in production to give highest overall effectiveness for one or several years of operation. It involves choices between alternative crops and livestock, alternative operations, and

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[1] War and agriculture (editorial), AGRICULTURAL ENGINEERING, vol. 20, no. 9 (September 1939).

[2] After the war (editorial), AGRICULTURAL ENGINEERING, vol. 21, no. 3 (March 1940).

[3] Farm operating efficiency (editorial), AGRICULTURAL ENGINEERING, vol. 21, no. 5 (May 1940).

alternative equipment. It suggests development of production and farm improvement plans and operating schedules based on cost records.

Farm management specialists and successful farmers have made substantial progress in this organization phase of improving farm operating efficiency. But again the material, energy, and time relationships, and the engineered structures and equipment involved are so important that agricultural engineers might help materially in developing principles, techniques, and related data on coordination of farm operations for high overall efficiency.

Probably least has been attempted and greatest opportunity is open for improving farm operating efficiency on a sound basis of applied science, in the matter of environmental influence on biological efficiency. Time and money are being spent on tillage, for example, with limited knowledge of the root environment it provides or of the resulting influence of separate factors in this root environment on yield and quality of crop products. Customary cultural practices may be followed with apparently satisfactory results, but there is little assurance that they are the best attainable, that any one or several individual operations may not represent a total loss, however efficiently they are performed, or that alternative or additional operations might not have resulted in more economic production. The same is true of investment in structures to control atmospheric environment for livestock, crops, or stored products.

As a basis for recommending one operation or another, one combination of production facilities or another, and one operating plan or another for farm operating efficiency, quantitative information is needed on the biological effects of environmental conditions, which can be related to product value and to costs of manipulations and controls to provide various degrees of approach to optimum environments.

This is a tremendous order for agricultural science, even if the research implied is confined to ranges of environmental conditions known to be generally favorable or tolerable to the most important farm crops and livestock. It calls for quantitative data on individual breeds, varieties, and strains of plants and animals, as to their reactions at various stages in their life cycles, to measured combinations, variations, and sequences of physical, chemical, and biological environment—soil, water, and atmospheric. Corresponding information is needed on weed and insect pests, and on pathogenic as well as useful microorganisms, as a scientific basis for increasing efficiency in their control.

Environmental cause-and-effect relationships are the very basis of farming, as distinguished from primitive dependence on the bounties of unaided nature. Much has been accomplished with limited and inexact knowledge, and it seems logical that farm operating efficiency can be increased considerably by more detailed and exact knowledge of these relationships.

Producing this information may be largely a matter for biologists, but developing its applications to improve farm operating efficiency is largely a matter of agricultural engineering. And agricultural engineers can help provide it by making known the kind of scientific data they need as a basis for applications, and by cooperating in the instrumentation and conduct of environmental control phases of biological research. Some such research is being done and more could be done. There may be considerable data already on environmental influences on biological production, which could be assembled for agricultural engineering use and also to show what additional information is needed.

Improvement in the efficiency of individual farm operations and in their coordination for increased overall efficiency of farm units is within easy reach by application and further development of well-established engineering techniques. It offers hope of fairly quick results.

The broader or additional approach of measuring influences of physical and chemical environment on biological efficiency, and relating these influences to costs and values of providing certain environments, is obviously a project for long-term research. But without progress in this biological approach, agricultural engineers might find themselves in an embarrassing subprofessional position of being experts as to how various farm operations may be performed most efficiently, while knowing comparatively little about why, where, when, or to what extent the performance of these operations may be economically justified.

North American Rubber

NATIONAL defense preparations have suggested serious consideration and investigation of the possibilities of the United States producing its own supply of raw rubber. Considering present and increasing knowledge of the chemical and physical structure of rubber, and the fact that synthetic rubber is already being produced in small quantities, the idea may not be too fantastic.

Looking ahead to the possible agricultural engineering implications of rubber production here, if the rubber tree has to be adapted to our subtropical regions there is little hope of early production, and any failure to mechanize cultural and sap-collecting operations might prove limiting factors in the ultimate success of the project.

There are many plants, however, which produce limited amounts of compounds comparable to rubber. Improvement of one of them, or of processes of extracting the rubber from them, might present entirely different agricultural engineering problems.

Another plausible idea is that synthetic rubber production might progress in the direction of using one or more of these natural rubbers, some closely related organic compounds, or even some entirely different organic substances as basic raw materials. In other words, the synthesis might be simplified and reduced in cost by starting with organic molecules similar to those of rubber or to parts of the rubber molecule. Chemical processing phases of the molecular assembly line might be shortened, and the initial phases performed by plants growing on American farms.

If the organic materials used were already market commodities, the agricultural engineering problem might simply be one of facilitating increased production. If the process required either better, or poorer and cheaper grades of commodities now marketed, adaptations of existing equipment and methods might solve the problem. If it involved plant parts not now harvested, harvesting at a different state of maturity, crops new to the farmers of this country, or new packaging, refrigerating, or preliminary processing operations, the agricultural engineering problems might be numerous, complicated, and highly important to the success of the venture.

The call for agricultural engineers to help this country produce its own rubber may not be heard tomorrow or next week, but it is one of many possibilities on which agricultural engineers can keep openminded.

Correction Notice

IN the paper on "Ultraviolet and Infrared Energy in Agricultural Practice," by L. J. Buttolph and L. C. Porter, in AGRICULTURAL ENGINEERING for May 1940, the figures over captions 5 and 6, page 180, are transposed.

Performance of Small Hammer Mills

By John E. Nicholas
MEMBER A.S.A.E.

THE performance tests on two small hammer mills[1], described in this paper, were carried out at The Pennsylvania State College according to the REA "Guarantee of Performance" outline, as follows:

Guarantee of Performance. In submitting proposals, the bidder will give a guarantee of the performance of the hammer mill by data giving the number of kilowatt hours per ton of feed ground. The feeds ground shall comply with the following U. S. Official Grain and Hay Standards:

Official grade	Weight per bu, lb	Moisture content, per cent	Cracked or damaged grains, per cent
	Wheat (soft red winter)		
2	58	15.5	4
	Corn (yellow, white or mixed)		
2	53	15.5	3
	Barley (Class I)		
2	46	14.5	8
	Oats (white, red, gray, black or mixed)		
2	30	16	0.3

Alfalfa

Official grade	Per cent leaves	Per cent green color	Maximum per cent foreign material
	Alfalfa, with not over 5 per cent grasses.		
2	25 or more	35 or more	10
	Soybean hay		
	Soybean hay with not over 10 per cent Johnson grass, or 15 per cent other grasses.		
2	25 or more	25 or more	15
	Clover hay		
	Clover with not over 20 per cent timothy, other grasses and/or grain hay.		
2	———	30 or more	15

The feeds shall be ground to medium fineness and fineness moduli (determined in accordance with the recommendations of American Society of Agricultural Engineers)[2] given in the following table:

Ear corn	3.60 or lower
Shelled corn	3.60 or lower
Barley	3.20 or lower
Oats	2.90 or lower
Soybeans	3.60 or lower
Wheat	3.20 or lower
Rye	2.90 or lower
Corn stover	3.50 or lower
Corn fodder	3.50 or lower
Soybean hay	3.50 or lower
Alfalfa	3.50 or lower
Clover hay	3.50 or lower

NOTE: Corn stover does not include ears. Corn fodder includes ears. For determining the input in kilowatt-hours, if test of 5 minutes or less, the kilowatt-hours shall be read to 0.001, on a kilowatt-hour meter having a multiplication factor of 0.01. The motor used shall not be overloaded, in accordance with the latest National Electrical Manufacturers' Association standards. The type, manufacture, size, and model number of the electric motor used in these tests shall be given.

An "evaluated price" of the cost of the grinding machine plus the cost of grinding (50) fifty tons of feed a year (different percentages for each type material, according to the local conditions combined to amount to fifty tons a year) at 2 cents a kilowatt-hour for energy consumption, will be the basis for evaluating bids.

Performance guaranteed must be consistent with the performance under operating conditions and with good manufacturing practice. In case of any reasonable doubt as to the ability of any bidder to meet the guaranties which he makes, the cooperative reserves the right to require further proof before approving bidder's proposal. This further proof may be either certified test data or a witness test of a hammer mill of similar design and capacity, constructed at the bidder's expense for such tests.

Installation. The bidder shall set up on the consumer's premises and operate the complete grinding machine as called for in the bid and specifications. If desired, the performance tests outlined below may be made on any or all grinding machines within a reasonable time after it has been installed and operated. In no event shall the test be delayed more than thirty days after the contractor notified the cooperative of the completion of the installation. Either the consumer or manufacturer has the right to call for a performance test. If test fails to meet the manufacturers' guarantee, the

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Paper No. 949 in the Journal Series of the Pennsylvania Agricultural Experiment Station, authorized December 27, 1939. This paper is to be presented before the Rural Electric Division at the annual meeting of the American Society of Agricultural Engineers, at State College, Pa., June 19, 1940; and is pre-printed to provide opportunity for study and discussion. The author is professor of agricultural engineering at Pennsylvania State College.

[1]These mills will be referred to as Nos. 1 and 2.

[2]In making a fineness modulus determination a 250-gram sample of ground feed is oven-dried at 100 C (degrees Centigrade) to a constant weight. The sample is then poured into the top of one of a set of standard Tyler 8-in screens having varying sizes of openings with the coarsest screen at the top and the finest at the bottom. The set is then shaken on a Ro-Tap shaker for 5 min. The amount of material retained upon each screen is then weighed. The fineness modulus or index is the sum of the percentages of feed coarser than each of the screens divided by 100.

FIG. 1 TEST SETUP IN FEED GRINDING ROOM OF THE BEEF CATTLE BARN, SHOWING MILL, MOTOR, AND BAGGING ASSEMBLY, WEIGHING SCALES, AND TABLES WITH ELECTRICAL INSTRUMENTS

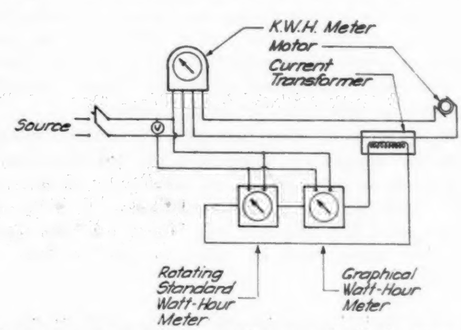
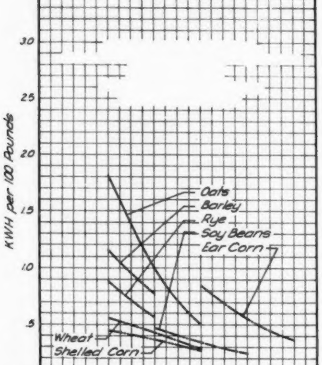
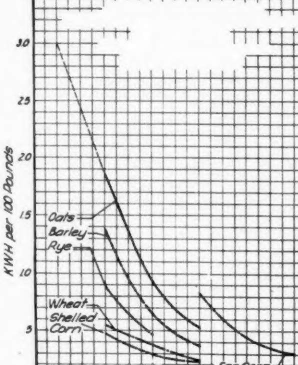
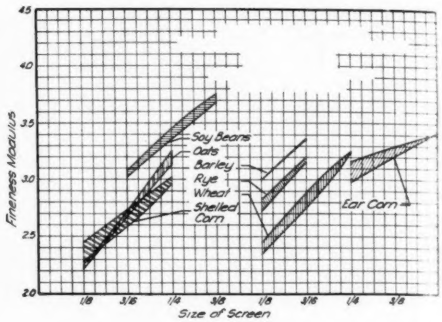


FIG. 2 WIRING DIAGRAM OF ELECTRICAL METERING INSTRUMENTS USED IN TESTS AND SHOWN MOUNTED ON TABLE IN FIG. 1







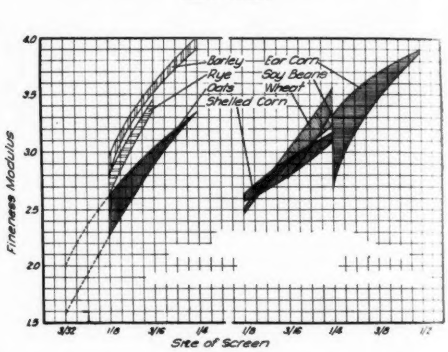


Fig. 3 (Left) Graph of comparative energy requirements per 100 lb for seven different grain feeds, with No. 1 mill. Fig. 4 (Center) Comparative energy requirements per 100 lb for six different grain feeds, with No. 2 mill (Data on soybeans fall so close to those of corn, in this case, that for the sake of clarity, they were not plotted.) Fig. 5 (Upper right) Fineness modulus for seven different grain feeds, with No. 1 mill, when plotted against screen sizes. Fig. 6 (Lower right) Variation in fineness modulus in seven different grain feeds with No. 2 mill, when plotted against screen sizes

manufacturer has to pay for the test as well as make the machine perform his guarantee or pay penalty.

The cooperative and the Rural Electrification Administration reserve the right to test any machine installed and financed under loans from the Rural Electrification Administration.

Performance Tests. Performance tests when required shall be designed to determine kilowatt-hour input per ton of ground feed. They shall be determined by capacity measurement, kilowatt meter input measurement, and fineness moduli of ground material, including all losses. The input to the motor will be measured by calibrated watt-hour meter having a 0.01 multiplication factor, to be furnished by the cooperative. In case of dispute between the contractor and the purchaser, the decision of an agricultural engineer approved by the Rural Electrification Administration and the manufacturer shall be final."

Preliminary Arrangement. Prior to the tests a survey of local farms was made to determine the availability of different farm materials which were to be included in the tests and to assure that these materials represented as nearly as possible average farm feeds. Two local farmers were able to supply soybeans, soybean hay, rye, and barley. All other materials, except several hundred pounds of additional soybeans, purchased in Ohio, came from the College farms department.

The feeds were sampled for analysis by C. O. Cromer, professor of farm crops, department of agronomy, who classified the feeds, determined their moisture content[3], official grades, and weight per bushel. To obtain representative samples from the quantities to be ground, a standard probe was used in sampling all grains. Table 1 shows the classification as determined by Prof. Cromer.

Test Apparatus. Two new mills complete, equipped with electric motors and controls ready for operation, including a full set of screens, were obtained from the manufacturer. Mill No. 1 was connected through a V-belt drive to a 2-hp type CR motor, and mill No. 2 to a 5-hp type CU motor. The speed ratio of motor to mill in both cases was 1 : 2.

[3]Moisture content for stover, alfalfa and clover hay was determined by Dr. R. W. Swift, professor of animal nutrition, Institute of Animal Nutrition, The Pennsylvania State College.

Fig. 1 shows mill No. 1 set up as used in the feed grinding room in the beef cattle barn during the test. Mill No. 2 was similarly arranged. Mounted on the table are the metering instruments: (1) a graphic watt-hour meter

TABLE 1. CLASSIFICATION OF FEEDS

Sample	Test weight lb	Moisture, per cent	Cracked or damaged, per cent	Foreign material, per cent	Odor	Grade
Local farm A, barley	42.5	14.1	Trace	8	Musty	U. S. Sample. Acct. odor and F. Mat. Also considerably stained.
College, wheat	57.5	12.3	7.3	0.67	O.K.	U. S. No. 3 S. red winter. Acct. test weight
Beef barn* No. 1 corn	53.0	12.2		2.02		U. S. No. 2 yellow corn Acct. test weight.
Beef barn, No. 2 corn	52.8	12.1				U. S. No. 3 yellow corn Acct. test weight.
College, oats	31.0	10.8	96 (Sound cultivated oats)			U. S. No. 2 and sound cultivated oats. Acct. test weight.
Beef barn*, oats	29.0	11.8	97.6 (Sound cultivated oats)			U. S. No. 3 Acct. test weight.
Local farm A, soybeans	56.5	10.7	7			U. S. No. 3 Acct. split beans.
Ohio soybeans	57.5	8.5				U. S. No. 3 Acct. split beans.
Local farm B, rye	54.0	11.6				U. S. No. 2 Rye Acct. test weight.

Official grade	Per cent leaves	Per cent green color	Maximum per cent foreign material
(Local farm A) Soybean hay — free from Johnson grass)			
U. S. No. 2	30	25	10
(Beef barn*) Alfalfa hay			
U. S. No. 2	45	40	3
(Mitchell barn*) Clover hay with 10 per cent timothy)			
U. S. No. 1		45	trace

*College barns

which served the principal purpose of providing a graphical indicator, showing at all times the exact instantaneous energy delivered to the motor; (2) a rotating standard watt-hour meter, with a start and stop-switch on the potential, which measured the electrical energy used for any desired length of feed grinding interval and read to 0.00001 kw-hr; (3) a standard a-c voltmeter; (4) a current transformer; and (5) a standard house-type, 30-amp 230-volt, kilowatt-hour meter. Fig. 2 shows the wiring diagram of electrical instruments. The purpose of the current transformer was to provide the metering circuit with a "step down" ratio to accommodate the maximum capacity of the graphical meter. Maximum capacity of the graphical meter was 1000 watts, while the maximum load to the 5-hp motor was to be maintained at 5000 watts, hence a 10 : 1 ratio was used to allow full-scale visibility and control.

A platform scale with a beam graduated to hundredths of a pound was used to weigh the ground materials. The tares for bags used to collect the ground grains were determined to the exact sensitivity of the beam scale, namely, one one-hundredth of a pound.

The speeds of motor and mill were obtained by an indicating speedometer and checked with a Veeder speed counter.

Time of operation was determined by a standard stop watch in all tests.

The dust collector had a two-sack bagger attachment which made it possible to fill either of the two bags, thus facilitating the exact measurements of ground grains for short intervals.

Test Procedure. Since both mills were ready for operation, it was only necessary to properly connect the motors through the metering instrument, to the single-phase, 220-volt line. A no-load test (Table 4) was made with each setup before any grain was ground. This also served as a check for correct operating conditions of the complete test units, including instruments.

The station assigned to the individual operator or attendant was retained throughout the test. Bagged grains were transferred to half-bushel containers by an attendant, maintaining a constant supply to the operator, who fed the mill at a constant load as indicated by the graphical watt-hour meter. One participant recorded the data and directed the "start" and "stop" of each test; the second maintained the load constant; the third measured the necessary speeds of the mill and motor during the run. All tests were made in duplicate. No test was shorter than 2 min, and some were as long as 10 min.

Obtaining samples from each test, drying these samples and determining the fineness modulus, were carried out according to the recommendations of the American Society of Agricultural Engineers. Fineness modulus was, however, obtained for every sample of feed as soon as it was ground (in order to determine the correct size screen for the approximate fineness modulus required) and after drying the samples. These are given in Tables 2 and 3.

The motor load at the beginning of each run was adjusted by increasing the rate of feeding the mill until the horsepower to the belt was equal to the rated horsepower of the motor, as indicated by the graphical watt-hour meter. This marked the start of test. The load was then maintained as nearly constant as possible throughout the test interval. In general the test interval was 2, 3, 4, 5, 6, or 10 min.

Results. Tables 2 and 3 show the results obtained from mills Nos. 1 and 2 when operated by 2 and 5-hp motors at constant loading, with the horsepower to the belt not exceeding the respective rated horsepower of the motors. All common farm grains and hays were included except fodder, which could not be handled because it was not reasonably dry for grinding purposes at the time of test. An attempt, however, was made to grind stover (tests 16, 16A, and 17), but after drying it was found to have contained 24.6 per cent moisture, and was apparently still too green to be handled by a hammer mill.

Mill No. 2 is capable of handling over a ton of feed per hour of wheat, soybeans, and shelled corn, through a ¼-in screen, grinding to a fineness of 3.23 to 3.56 for wheat (tests 20 and 20A), 3.36 for soybeans (test 14), and 3.09 to 3.17 for shelled corn (tests 26 and 26A).

To grind wheat to a fineness of 3.20 or lower required the 3/16-in screen, which decreased the capacity of the mill nearly 32.5 per cent, compared to the ¼-in screen. A fineness less than 3.6 was obtained with the ¼-in screen with soybeans, and with shelled corn, maintaining a ton-per-hour capacity. A ⅜-in screen for shelled corn would

TABLE 2. RESULTS FROM NO. 1 HAMMER MILL WITH 2-HP TYPE CR MOTOR

Test Nos.	Feed	Per cent mois- ture	Size of screen, in	Fineness modulus, dry	Lb per hour	Kw-hr per ton
101, 101A	Oats	10.8	1/8	2.25, 2.22	109.2, 111.5	36.60, 36.20
102, 102A	Oats	10.8	3/16	2.74, 2.68	197.4, 196.2	20.40, 20 60
103, 103A	Oats	10.8	1/4	3.26, 3.14	396.8, 397.2	10.22, 10.06
104	Soybeans (Ohio)	8.5	3/16	2.67	623.4	6.51
104A, 104B	Soybeans (Pa.)	10.7	3/16	3.02, 3.08	365.4, 377.0	11.04, 10.56
105, 105A	Soybeans	10.7	1/4	3.46, 3.36	586.8, 589.2	6.80, 6.82
106, 106A	Soybeans	10.7	3/8	3.76, 3.69	765.6, 755.0	5.18, 5.14
107, 107A	Shelled corn	12.2	1/8	2.28, 2.45	446.2, 450.0	8.90, 8.98
108, 108A	Shelled corn	12.2	3/16	2.59, 2.74	560.4, 554.6	7.22, 7.64
109, 109A	Shelled corn	12.2	1/4	2.97, 3.03	768.0, 776.6	5.52, 5 22
111, 111A	Wheat	12.3	1/8	2.35, 2.45	355.2, 352.0	11.32, 11.36
112, 112A	Wheat	12.3	3/16	2.76, 2.89	472.2, 456.0	8.52, 8.70
113, 113A	Wheat	12.3	1/4	3.24, 3.25	687.0, 727.2	5.82, 5.60
120	Wheat	12.3	1/4	3.12	855.6	5.74
114, 114A	Barley	14.1	1/8	3.00, 3.00	170.0, 164.0	23.20, 23.80
115, 115A	Barley	14.1	3/16	3.37, 3.38	249.2, 255.4	15.70, 15.50
116	Ear corn	11.8	1/4	3.16	230.0	17.50
116A	Ear corn	12.4	1/4	2.98	251.4	16.82
117	Ear corn	13.4	1/2	3.42	610.8	7.30
118, 118A	Rye	11.6	1/8	2.83, 2.72	234.0, 216.2	17.30, 18.32
119, 119A	Rye	11.6	3/16	3.20, 3.16	355.6, 352.0	11.44, 11.52

Duplicate tests under identical conditions as to feed ground, per cent moisture, and screen size are shown on the same line, with test numbers and results separated by commas and in corresponding order.

TABLE 3. RESULTS FROM NO. 2 HAMMER MILL WITH 5-HP, TYPE CU, MOTOR

Test Nos.	Feed	Per cent mois- ture	Size of screen, in	Fineness modulus, dry	Lb per hour	Kw-hr per ton
1, 1A	Oats	10.8	1/8	2.63, 2.26	256.8, 295.8	39.80, 35.00
2, 2A	Oats	10.8	3/16	2.89, 3.04	553.3, 539.0	18.70, 18.70
3, 3A	Oats	10.8	1/4	3.36, 3.36	912.4, 1033.0	11.04, 9.88
23, 23A	Oats	11.8	3/32	2.05, 1.56	180.0, 164.0	58.40, 61.80
24	Oats	11.8	1/8	1.97	240.0	43.80
5, 5A	Rye	11.6	1/8	2.63, 2.81	574.8, 564.0	17.80, 17.84
4, 4A	Rye	11.6	3/16	3.37, 3.46	1109.0, 1143.4	9.42, 9.14
14, 14A	Soybeans (Ohio)	8.5	1/4	3.36, 3.36	2046.0, 1950.0	4.52, 4.08
15	Soybeans	8.5	3/16	2.78	1765.5	5.82
18, 18A	Barley	14.1	1/8	2.77, 2.96	382.2, 376.6	27.40, 27.80
19, 19A	Barley	14.1	1/4	3.91, 4.01	1384.0, 1406.4	7.28, 7.42
28, 28A	Barley	14.1	3/16	3.51, 3.59	764.8, 784.0	13.12, 12.84
20, 20A	Wheat	12.3	1/4	3.23, 3.56	2103.0, 2136.0	4.94, 4.64
21, 21A	Wheat	12.3	1/8	2.46, 2.52	960.0, 918.12	10.82, 11.22
22, 22A	Wheat	12.3	3/16	2.90, 3.02	1361.4, 1342.2	7.62, 7.64
25, 25A	Sheled corn	12.2	1/8	2.64, 2.58	1108.2, 1104.0	9.42, 9.30
26, 26A	Shelled corn	12.2	1/4	3.17, 3.09	2233.5, 2215.5	4.64, 4.70
27, 27A	Shelled corn	12.2	3/16	2.79, 2.94	1754.1, 1827.0	5.88, 5.84
29, 29A	Ear corn	11.1	1/4	2.69, 3.32	643.2, 606.6	16.20, 17.28
30, 30A	Ear corn	11.8	3/8	3.45, 3.69	1236.0, 1104.0	8.56, 9.06
31, 31A	Ear corn	11.2	1/2	3.83, 3.89	1760.0, 1640.0	5.94, 6.10
31B	Ear corn	11.2	1/2	3.99	1800.0	6.24
6, 6A	Soybean hay	10.7	1/4	3.10, 3.10	276.00, 276.0	41.00, 42.20
7	Soybean hay	10.7	1/2	3.68	696.6	14.58
8, 8A	Alfalfa	12.3	1/4	2.51, 2.51	377.4, 540.0	26.20, 19.20
8B	Alfalfa	12.3	1/4	2.51	576.0	19.92
9	Alfalfa	12.3	1/2	3.18	880.0	9.78
10, 10A	Alfalfa	12.3	3/8	2.74, 2.74	822.4, 918.0	10.78, 10.26
11, 11A	Clover hay	14.0	3/8	3.14, 3.14	828.0, 884.3	14.04, 13.30
12	Clover hay	14.0	1/2	3.01	1047.2	9.56
33, 33A	Clover hay	14.0	1/4	2.66, 2.66	629.0, 600.0	16.1 , 16.0
16, 16A	Stover	24.6	3/8	4.09, 4.09	179.2, 161.4	71.8 , 70.8
17	Stover	24.6	3/4		223.0	53.6

Duplicate tests under identical conditions as to feed ground, per cent moisture, and screen size are shown on the same line, with test numbers and results separated by commas and in corresponding order.

give a fineness less than 3.6, with a possible and perhaps very appreciable increase in mill capacity; however, the ton-per-hour limit was set by the fan.

Figs. 3 and 4 show graphically the comparative energy requirements per 100 lb of various grains ground, when plotted against mill screen sizes.

Comparing Figs. 3 and 4, it is found that mill No. 2 is slightly more economical in its overall operation, based on kilowatt-hours consumed per 100 lb of feed ground.

Oats is the most difficult and expensive grain to grind with either mill. Shelled corn, soybeans, and wheat are the easiest to grind and least expensive.

TABLE 4. NO LOAD TESTS

Test	Number of mill	Motor, hp	RPM of mill	RPM of motor	Energy required to run mill empty, watts
A	2	5	3720	1800	1588.8
B	2	5	3721	1806	1452.0
C	–	5	——	1825	739.2*
D	1	2	3680	1780	716.0
E	1	2	3675	1790	696.0

*Energy to motor, without mill

Figs. 5 and 6 show the variations in fineness modulus for the different grains obtained from mills Nos. 1 and 2.

Fig. 5 indicates that mill No. 1 gave, on the average, more uniform grinding than mill No.2, as shown in Fig. 6. In general, barley was ground most uniformly by both mills, while the greatest variation resulted with ear corn, as might logically be expected, since no two ears of corn are uniform in size; hence the feeding to the mills is not gradual but by "gulps" or "bites."

The shaded areas in Figs. 5 and 6 are drawn to indicate the approximate fineness modulus of materials ground that might be expected from a screen. For example, with mill No. 2 using a 1/8-in screen, with wheat the variation is from fineness number 2.46 to 2.52; with a 3/16-in screen, 2.90 to 3.02; and a 1/4-in screen, 3.23 to 3.56. These variations in fineness modulus are probably influenced by per cent moisture, rate of feeding, speed of the rotating hammers, and size of kernels.

Tables 2 and 3 give summary results for both mills. This includes mill screen sizes, per cent moisture, fineness modulus after drying, pounds of material ground per hour, and kilowatt-hours per ton.

OBSERVATIONS ON TEST RESULTS

1 It was not possible to duplicate exactly the fineness modulus or hourly capacity of the mills with the same grain using the same screen and maintaining a constant load on the motor (Tables 2 and 3, Figs. 5 and 6).

2 The exception to the above observation is with barley, mill No. 1 (Fig. 5), and soybeans, mill No. 2 (Fig. 6).

3 Since both exceptions, stated in item 2, do not hold with the same grain and both mills, observation in item 1 is substantiated.

4 The same kind of grain, but differing in moisture content and specific weight, will vary the mill capacity and fineness modulus, if ground by the same mill and same screen, other factors being equal as shown in tests 104, 104A, 104B (Table 2).

5 The hourly capacity of mill No. 1 for soybeans in test 104A is 41.4 per cent less than in test 104.

6 The greatest variation in fineness modulus was found to be with ear corn. A 1/4-in screen gave a fineness as low as 2.83 and as high as 3.32.

7 Mill capacity, when grinding hay or similar materials, shows greater variation than with grains, since uniformity of feeding became more difficult.

Training Builders

By C. T. Bridgman
MEMBER A.S.A.E.

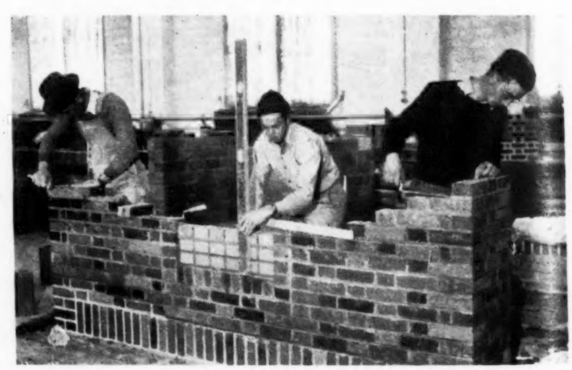
THE building industry is constantly being accused of inefficient, obsolete methods, high costs, and poor finished products. Many of these accusations are false; however, leading contractors, architects, engineers, and building materials manufacturers admit there is an opportunity for improved utilization of materials which would result in reducing construction costs. Since from 25 to 40 per cent of the cost of a completed building is in labor on the job, training better workmen would seem to be one of the first steps in improving the quality of construction and reducing the costs of the finished building.

For the first time, so far as we know, instruction is being given to apprentice bricklayers in a short-course at a state college. Iowa State College has enrolled 34 bricklayer apprentices in a course which consists of half-time actual experience and half-time studying related technical subjects. This short-course was made possible by the cooperation of three organizations active in the building industry: The Master Builders Association of Iowa, Structural Clay Products Institute (Region 1-W), and the Bricklayers, Masons and Plasterers International Union.

The three groups met several times to try and develop a plan for supplementing the training the apprentices were getting on the job, which all agreed was insufficient. The plan developed called for a nine weeks' short-course at Iowa State College under the supervision of the engineering extension service and the state board for vocational education. The course is open to any boy who is a regular indentured apprentice and has been in the trade at least six months. Most of the boys' expenses are paid by the Structural Clay Products Institute and the Master Builders Association. The course is not restricted to union apprentices.

The manipulative work is taught by two skilled journeymen, and the related technical work, such as blueprint reading and testing of materials, is taught by a faculty member on special assignment from the division of engineering. President Friley of Iowa State College believes this may be a trend in education and a responsibility that must be assumed by the technical colleges. Certainly a school of this type will do much to eliminate any inefficiency and waste on a job and help to produce better buildings at a low cost, which will in turn create more work.

The author is regional director, Structural Clay Products Institute.



Three of the advanced boys lay up a face brick section which affords experience with corners, recessed header panel, and Flemish bond. All are sons of bricklayers and are high school graduates who would like to be foremen some day

The Mechanization of a Southern Plantation

By H. H. Hopson, Jr., and Wm. E. Meek
MEMBER A.S.A.E.

IN APPROACHING the subject of the mechanization of a southern cotton plantation, we believe that engineers would be more interested in the problems arising and their solution, than in cost figures. It is a simple matter to give figures. They can be obtained from a number of sources, and some will be exceptionally low while others may be high. We will endeavor to give you a picture of the transition from mules to power on one plantation located in the heart of the Yazoo-Mississippi Delta near Clarksdale, Mississippi, in Coahoma County. The Delta extends from just south of Memphis almost to Vicksburg, and is bounded on the east by the hills and on the west by the River. It is particularly adapted to the growing of long-staple cotton of an excellent quality. The fertility of its soils can scarcely be equaled. This plantation has been cropped to cotton for almost a century, and though soil improvement methods have been practiced for only a comparatively few years, yields are still maintained.

The plantation is about evenly divided into three distinct soil types. There is the heavy delta "buckshot"; a heavy, sandy loam; and a brown sandy loam. The latter is our best cotton land. It is also the easiest worked. The general drainage slope is away from the River and has a fall of about three or four feet per mile. Heavy rainfall and a slow runoff make drainage a real problem.

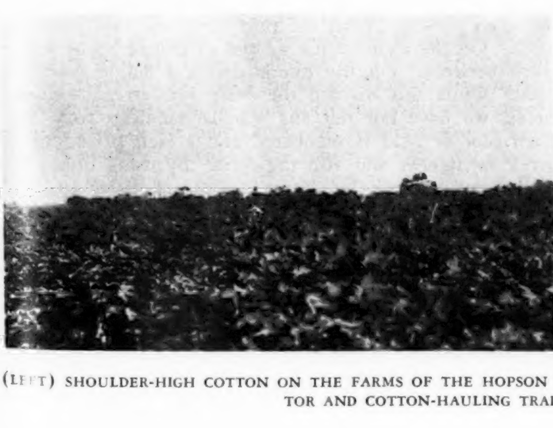
We are operating 4,000 acres and under normal conditions a plantation of this size would have from 2,000 to 2,500 acres of cotton. Under the acreage-reduction program we now have about 1,500 acres in cotton. Other acreages include 800 acres in timber, 600 acres which we are now fencing for permanent pasture, 500 acres in oats and barley, primarily for seed, 125 acres in alfalfa hay, 70 acres in burr clover for seed for soil improvement, and usually about 200 acres in soybeans. A few beans are harvested, but this crop is planted to be turned under. The remaining acreage is used for experimental crops and for improvements where it is necessary that the land not be cropped while this work is going on. Naturally a number of acres are absorbed by roads, ditches, and buildings.

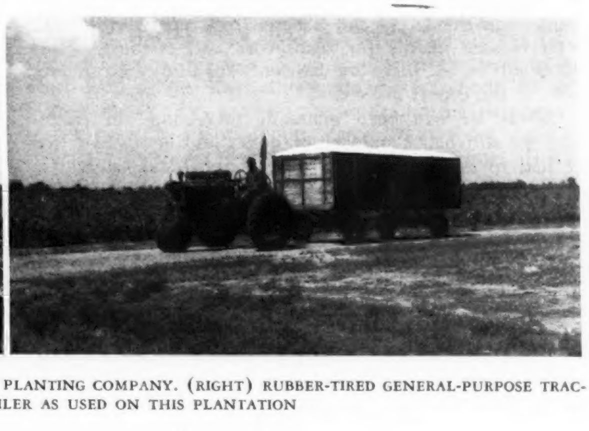
For most of the past two generations we were forced to operate with mules, as no mechanical power was available. Our first tractor was purchased in 1914. This was a small track-type machine and was used for breaking and disking. With the advent of the first low-cost wheel tractors several were purchased and a tractor fleet begun. These comprised our fleet until 1927, when a 15-30 tractor was put into operation. In 1920 and 1921 we used two motor-cultivator outfits and made the first all-power cotton crop in this section. These outfits were far from perfect and were discarded after two years of use. Also in 1927 we put our first general-purpose tractor in operation. A lack of equipment made this another tractor for plowing and disking. No equipment was available suitable for our crops or conditions. Implements imported from the corn belt were not satisfactory, nor were they strong enough to stand up in our heavy soils. The years from 1927 to 1929 we spent waiting for equipment to be made available. Early in 1929 this much needed equipment was made available, and we immediately increased our fleet to six general-purpose tractors, all with four-row cultivators. Here we began to keep costs in an effort to determine whether or not it would be advantageous to eliminate all mules and go to mechanical power one hundred per cent.

A careful study was also made of mule costs. We found this an almost impossible task, mainly because of the tenant system. A quite extensive study was made of our plantation records for a number of years and a figure derived that we felt could be safely used as a basis for comparison. After this comparison we came to the conclusion that we could produce cotton from 25 to 33 per cent cheaper with tractors than we could with mules. Tractor and mules costs will be very close to the same figure, but the acreage necessary for raising feed for mules is made available for cash crops. The labor of making this feed crop is also an item. A plantation the size of ours required from 200 to 250 mules, with all the necessary gear and equipment, to say nothing of barns and storage space for feed. Perhaps we are a bit lazy, but we would rather service twenty tractors than 200 mules.

We also found that our yields per acre increased with

Presented before the Power and Machinery Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 5, 1939. The authors are, respectively, manager of the Hopson Planting Company, the operations of which are described in this paper, and special representative, tillage and seeding machine sales, International Harvester Co.





(LEFT) SHOULDER-HIGH COTTON ON THE FARMS OF THE HOPSON PLANTING COMPANY. (RIGHT) RUBBER-TIRED GENERAL-PURPOSE TRACTOR AND COTTON-HAULING TRAILER AS USED ON THIS PLANTATION


(LEFT) TRACTOR STORAGE SHED AND SERVICING SET-UP OF THE HOPSON ORGANIZATION. (RIGHT) MODERN COTTON GIN USED EXCLUSIVELY FOR GINNING THE COTTON OF THIS ONE FARM

tractor operation. This is due to a number of factors. In recent years we have been planting only the soils best adapted to cotton; we have better seed and seed treatment; insect control is far superior to what it was a few years back; fertilizers are better adapted; we do a better job of seedbed preparation; a more uniform and quicker job of planting; cultivation is cleaner and faster; and there is the timeliness of speedy tractor operation. This may be the difference between a crop and a failure in years of adverse weather conditions. For the past three years we have an average yield of 685 lb of lint cotton per acre, and the crop just harvested averaged 730 lb per acre. There was a time when we would have been well satisfied with from one-half to three-quarters of a bale per acre, and would have considered a bale per acre a very good crop.

The depression years from 1929 to 1933 prevented our expanding our tractor operations, but the outfits we already had were operated and costs carefully kept. Much valuable information was gained during this time which has been used in later years. We felt that steel-wheeled tractors were not quite what we needed, but there was no other wheel equipment available. Our longest distance from headquarters is about 3½ miles, but it is not unusual for an outfit to have to travel 5 or 6 miles over hard plantation roads. On steel wheels this must be slow, and the vibration was apt to increase repair costs both to tractor and implement. With the introduction of pneumatic tires in 1934 we felt that this obstacle had been removed, and we immediately increased our fleet of general-purpose tractors to nine. Here we started a program of complete mechanization. The following year, 1935, we purchased six more outfits, bringing the fleet to fifteen. We now have twenty general-purpose outfits, and the 15-30 and a large track-type tractor. The latter is used mainly for road work and ditching. Nine mules still on the place are used only for bringing full pick sacks to the cotton pens.

While we had been gradually increasing our tractor fleet, we still had a number of mules and equipment that we had to dispose of. We were fortunate in catching a slightly rising mule market. The various implements we endeavored to sell to neighboring mule farmers. Finally a sale was held and all salable machines sold. What was left we scrapped. While we could not hope to obtain full value, a satisfactory disposition was made. Thus was one problem solved.

We had learned something about field planning and drainage, and had at least made a start in that direction. We found that we had to have an entirely different set-up for tractor operation. Tenant houses and cotton pens dotted the fields and seriously impaired the efficiency of large four-row outfits. It was decided to remove all of them. The tenant houses we moved to the banks of Sunflower River which borders the plantation or to the nearest property line. Cotton pens were wrecked and the lumber salvaged. Where the lumber was not worth salvaging a match did the moving job quickly and efficiently. As the tenant houses were moved they were repaired. Galvanized iron roofs were put on. The outside flues and chimneys were replaced by approved galvanized flues. Fireplaces gave way to heaters. The houses were ceiled, painted, and fitted with standard door and window casings which we had prefabricated in our shop. We had more attractive homes for our tenants, easier to heat, and the fire hazard was reduced to a minimum.

We are now using portable cotton pens of our own design and manufacture. These pens are readily moved with a light tractor. They hold a little over a bale of seed cotton and have the advantage that the top may be rolled forward, allowing the fresh-picked cotton to be exposed to the drying action of the sun. When the top is closed, complete protection is afforded. The sides are ventilated for air circulation. When not in use in the cotton fields, we use these pens for the storage of other crops.

Many a planter has dreamed of having his plantation divided into 40-acre blocks with a turn row or road on each side. We proceeded to lay out our fields in this manner. We found this most satisfactory in crop planning, tractor operations, and harvesting and hauling.

After several years we found that we were a long way from having a good drainage plan. A careful survey was made of the entire plantation, and the natural drains were located. These we classified as major and minor drains. We then plowed up all the turn rows and laid them out anew. On the main drains we put in double roads with a ditch between. On the minor drains a single road was used. While this divided the place into irregular-shaped fields, we have not felt any serious handicap from this. Each plot or field is numbered and a sign placed which gives its number and also the acres. By using broad, flat ditches we can handle a large volume of water and still cross them. Row direction or length was not materially changed. We are also able to work our roads and ditches without damage to the growing crop. We feel that our drainage system is now efficient.

Concentration of our equipment at a central point was felt to be advisable. We already had a large fireproof store or commissary located near both the railroad and the highway. This was selected as our headquarters site. The store also houses our offices. A gin of the latest design, with all

modern attachments such as cleaners and driers was erected near the spur track. A seed house was constructed in connection so that seed might be blown into the house for storage until shipped to the oil mill by rail or truck. A small house was erected for the storage of pick sacks and miscellaneous small equipment. There is also a seed storage warehouse, a shop, a trailer shed, and a tractor shed. All buildings are of galvanized iron and fireproof. This concentration saves time in many ways and allows much closer supervision.

A plantation the size of ours will ordinarily require from 165 to 175 families. Because of the hand labor involved in chopping and picking a cotton crop, it is not feasible to eliminate the tenants. An efficient cotton picker may change this picture materially.

Labor from nearby towns is unsatisfactory and not always available. The tenant system has been in use in the South for generations, and it is sometimes hard to change the customs of years. We felt that a modification of this system adapted to our operation would be the best solution to our problem. Such a plan would have to be acceptable to ourselves as landlords and to the tenants as well. Under the usual system the landlord furnishes the land, seed, fertilizer, poison, mules, feed, equipment, house, and fuel. The tenant works and harvests the crop with any additional labor and picking being charged to him. The yield is then divided on a fifty-fifty basis. Under our modification of this plan we furnish the land, seed, fertilizer, house, and fuel. All work of making the crop is done with tractors, except chopping and picking. All power operations are charged to the tenant at cost, which includes the actual costs of fuel and labor, plus depreciation and repairs. This has been figured over the years to where we feel our charges are about as near right as it is possible to get them. Any extra labor in chopping or picking is also charged. Power costs cover such operations as breaking, middlebusting, disking, fertilizer application, planting, cultivation, insect control, and hauling. The crop is divided as usual on the fifty-fifty basis. Our tenants seem to be well pleased with this plan and make as much or a little more than those on plantations operating with mules. As the tenant has more time out of his crop, he is available for day labor on the plantation. Oftentimes he can also pick up some extra money on outside jobs.

CENTRALIZED TRACTOR AND EQUIPMENT MAINTENANCE

As our fleet of tractors grew, the need of adequate service became more evident. A shop was constructed equipped with regular shop equipment and special tools as needed. It is a composite repair shop, machine shop, blacksmith shop, and woodworking shop. An efficient mechanic is in charge and usually has one or two helpers. Common repair parts are kept available so that repairs can be quickly made. Very few jobs are done in the field. Only minor repair jobs are allowed away from the shop. Tractors are brought in where the work can be done correctly. All power equipment is given a periodic check and repairs made as indicated. Complete overhauls are made at intervals, usually about every two and one-half to three years. We feel that our shop is a paying investment and would not want to be without it. Loss of time is cut to a minimum.

The trailer shed houses the trailers and is invaluable. Here the trailers are stored out of the weather when not in use. Loaded trailers are housed in the sheds overnight. Housing of tractors and implements is taken care of by the tractor shed and the enclosure about it. We have about 2.7 acres enclosed with cyclone steel fencing. The enclosure measures 240 by 500 ft. In the center is a shed of structural steel, with a galvanized roof, that measures 40x250 ft. Tractors are housed under the shed, while implements not in use remain on the lot. When the season's work is completed for an implement, all parts apt to be damaged by rust or exposure are removed. The implement is placed on trestles ready to be attached to the tractor and parts such as spring trips, planter hoppers, and coulters, are repaired and waiting in a 20x40-ft storage room near the center of the shed. Implements are painted at intervals and we are of the opinion that this is cheaper than storage inside. Tractors are stored under the shed.

When from ten to twenty high-speed tractors with four-row outfits mounted on them come in from the fields and concentrate at one shed, there is every opportunity for them to tangle, even with careful operators. The shed is divided into numbered stalls and each tractor has its own stall. To have uniformity of storage under the shed and to prevent accidents, we have constructed simple guides for each stall. Two 2-by-12s, 12 ft long are staked to the ground with a 2-by-10 of the same length edgewise between them. The top side of this 2-by-10 is beveled. At the inner end of this runway is a stop block. A driver simply straddles this beveled 2-by-10 with his front wheels and drives in until the stop block is reached. The tractor is then straight and properly spaced. There is room enough to take six-row equipment if it is ever available. Boards are provided for the rear wheels, and when the tractors are equipped with chains these are moved to the center out of the way. There is a satisfaction in having tractors stored in this uniform manner, and to date we have had no accidents.

FUEL AND LUBRICATION SERVICE PLAN

The servicing of a fleet of tractors can be quite a job unless some system is worked out and equipment made available. Next to the storage room in the shed is a small grease and oil room. Here we have an air compressor which furnishes air for the grease guns and tires, as well as for cleaning operations in the gin and shop. Just outside is a trestle with overhead pipes for fuel, water, air, and grease. Grease is stored in the room in 400-lb drums, and the air compressor has a maximum pressure sufficient to give a grease pressure of 8,000 lb per sq in, so that greasing is fast and efficient. Oil is stored here, also in drums, and put in the tractors in the usual manner. Gasoline is used for fuel and is pumped from tank cars or trucks into a 14,000-gal tank. It is fed to the tractors through a recording meter by gravity. With this set-up we can service a tractor alone in about 3 min, and when a four-row cultivator is mounted, increasing the number of grease fittings to be serviced to about thirty-five or torty, it takes from $3\frac{1}{2}$ to 4 min. This may seem a bit fast, but our drivers have become efficient in this work and it really is simple. A driver cranks his tractor in the stall and drives to the service stand. He fuels without leaving his seat. Two men with grease guns go down each side of the outfit, while another checks the oil. Still another checks the radiator water and the air pressure in the tires. We have found that it takes about one-half pound of grease to thoroughly lubricate a tractor. This is charged to the tractor by number. When a drum is empty the difference between the charge-outs to tractors and the original weight of the drum is charged to the implements. Fuel and oil are charged to the tractor by number. Cards are used to make these charges and each tractor has its own card. By this system we keep a close check on this phase of our operating costs.

Normally it would be simple to plan our crops—just cotton. Acreage reduction programs have changed all this. We have never felt that our soils *(Continued on page 217)*

Engineering Aspects of Farm Planning

By W. E. Hudson

JUNIOR A.S.A.E.

LEADING men in southern agriculture have long recognized the need for a balanced agriculture. During the past few years many statistics concerning the South's economic situation have received widespread publicity. Typical statements are: "The southern states have more than one-half of the nation's farm people, yet they raise less than one-third of the nation's pigs and cattle"; "The South with more than one-fourth of America's total population, produces only one-fifth of the nation's milk, eggs, and butter, one-seventh of the hay, one-eighth of the potatoes, and one-twelfth of the oats."

Georgia, fairly typical of the southern states economically, also has its share of the widespread problem of controlling erosion. Of the total land area in Georgia, exclusive of large cities and bodies of water, some sixty per cent is affected by sheet erosion, and over fifty per cent is affected by gullying.

The purpose of farm planning is to put a farm business on a more self-sufficient basis, and at the same time conserve and build up the resources of a particular farm. Food needs of the family and livestock are the foundation of the plan. Upon this foundation is built a system of farming which tends to balance soil-depleting crops with soil-conserving crops, which replaces soil fertility losses with soil fertility gains, and which offsets the hazardous gamble of single-crop farming with a cautious but ever-broadening diversification of enterprises. Through proper planning, real farm income should increase first, with net cash increases following closely.

TRAINING MEN FOR FARM PLANNING WORK

In an effort to adequately meet this problem, a cooperative plan has been evolved which makes it possible for teachers of vocational agriculture, county agents, members of the Soil Conservation Service, and others to work together in helping farmers to set up farming programs. It is of interest to note that the district supervisors of the several soil conservation districts in Georgia, representing the farmers of these areas, requested this service.

Since specific preparation is needed to help the farmer in planning work, a training program has been developed with the objective of giving prospective agriculture teachers, county agents, soil conservation technicians, and other agricultural workers the ability to deal with the major problems of farm planning in the light of the human and economic potentialities, as well as of the soil and other natural resources on the farm. Special reference is placed on the conservation of soil and water. This training program has been made possible through the initiative of the vocational education department, University of Georgia, with the cooperation of the College of Agriculture, the U. S. Soil Conservation Service, and other interested agencies.

In conducting the training program the procedure is usually as follows: The trainees go over a selected farm and examine it closely, each making a conservation base map showing field use, soil type, land slope, and degree of erosion. An economic survey of the farm and the farmer's resources is also made. This survey covers such items as family, farm home, grounds, outbuildings, farm acreage, machinery, the scope, production and value of enterprises, cropping practices, livestock practices, farm expenses, and a financial statement. A water-disposal map showing the approximate location of the terraces needed, terrace outlets, water-disposal areas, meadow strips, field road routes and permanent strips is made by the student.

From the information thus gathered, the trainee then evolves a farm plan showing the general direction in which he believes the farm operations should move in order that the greatest possible return, commensurate with sound land use, may be realized. A cropping plan to provide a living for the persons and livestock on the farm is worked out. The enterprises introduced by the trainee must be an integral part of the whole. Through this intensive study the shortcomings of the student are brought forcibly to his attention and a genuine desire for self-improvement is stimulated.

COOPERATION OF SPECIALISTS IN DEVELOPING FARM OPERATING PLANS

A technical staff, as provided by the College of Agriculture and the Soil Conservation Service, also go over the farm in question. Each member of the staff forms opinions concerning the farm, from his particular viewpoint or specialization. Since the staff is comprised of individuals in the fields of animal husbandry, soils, crops, farm management, forestry, horticulture, poultry, plant pathology, home economics, and agricultural engineering, the farm is well covered from all angles. A panel type discussion in which the technical staff and the farmer participate, with the student trainees as an audience, then provides the best solution that the combined minds of the group as a whole can formulate. Usually six to eight hours are devoted to this discussion. As problems are threshed out, questions answered, opinions given, and technical recommendations made, the student trainee receives the answers to his problems and can watch his own recommendations either rise or fall in the favor of the group. He sees a solution attained. He also sees the process of reasoning which brings about that solution.

Through these panel discussions certain phases of agricultural engineering have been highlighted. It is of interest to note what contributions the agricultural engineer may make in this work. Since the central theme of farm planning is self-sufficiency and proper land use, the soil conservation side of agricultural engineering has received the greatest attention. Development of the best water disposal system which will tie into the proper cropping plan is the agricultural engineer's main contribution. By the use of vegetation to replace expensive mechanical structures in outlets, the engineer has been able to promote greater use of all control measures. Since proper outlet control has been made more feasible for a wider group of the farming population, the ability of the agricultural engineer to be of service has multiplied many times. The terrace system of the present is better, yet more flexible, than ever before. It can be varied to suit both the farm and the farmer. It can be constructed piece- *(Continued on page 218)*

Presented before a meeting of the Southern Section of the American Society of Agricultural Engineers at Birmingham, Ala., February 7, 1940. The author is instructor in agricultural engineering, University of Georgia.

Determining an Index of Supplemental Irrigation and Its Application

By F. E. Staebner
MEMBER A.S.A.E.

IRRIGATION is being found profitable in many parts of the central and eastern states where normal rainfall is adequate for the seasonal requirement of crops. Primarily, this is because the precipitation is distributed irregularly, whereas crop need is fairly continuous throughout the growing season. Yet the need for artificially supplementing the rainfall is not uniform over any considerable area, nor is it proportional to the severity of occasional drought periods. Provision of facilities for irrigation involves a considerable investment, which in some years may prevent large loss of value in crops but in other years may not be used at all. So supplemental irrigation, while profitable in many localities, may not be profitable in all sections of the humid region.

The question then arises as to how to determine whether supplemental irrigation will be profitable in any locality. A number of attempts were made to devise an irrigation index that would take account of all of the many factors concerned, such as rainfall, rainfall intensity, soil type, soil moisture content at time of rainfall, surface slope, direction of slope, humidity, temperature, wind movement, atmospheric evaporating power, type of crop, growth cycle of the crop, season of normal harvest, hours of sunshine, intensity of solar radiation, etc. The efforts to consider these many factors, all of which could be expected to have some

Paper to be presented before the Soil and Water Conservation Division at the annual meeting of the American Society of Agricultural Engineers at State College, Pa., June 19, 1940. The author is drainage engineer, Bureau of Plant Industry, U. S. Department of Agriculture. The research on which this paper was based, and preparation of the paper were done while the author was with the former division of drainage, Bureau of Agricultural Engineering, which division is now in the Soil Conservation Service.

MOISTURE DEFICIENCIES IN MICHIGAN, AS A 30-YEAR AVERAGE BASED ON CROP USE OF 0.10 IN OF MOISTURE PER DAY

bearing on the ultimate irrigation need, lead to such complexity that it was obvious that inclusion of any important number of them would result in a procedure that would be totally impracticable to use for any ordinary purpose.

Accordingly, an effort was made to simplify the method to such readily determinable factors as would appear to give an index, which, if not perfect, would give a useful indication. This was done with the feeling that the resulting index would be better than the existing lack of any effective guide in choosing those localities where irrigation might or might not offer the possibility of being profitable.

Careful consideration of the various factors leads to the belief that rainfall and the resulting distribution of rainfall were extremely important factors, and that they had the further advantage that definite records of precipitation were available for many localities in the United States. As it seemed likely that a simple and useful index of irrigation need could be determined from rainfall, a method of doing this, as here outlined, has been developed tentatively by the Soil Conservation Service. The method takes cognizance of both duration and severity of drought during periods of moisture shortage, and gives a fair indication of the relative value of supplemental irrigation in various localities.

This method is based on two assumptions, namely, (1) that during the growing season crops have a daily average moisture requirement for best growth, and (2) that a day's rainfall of any particular amount makes an addition to the soil moisture, which for the purpose of simplifying this analysis, is assumed to be used by plants at a uniform rate through a certain number of days following that rainfall. It is recognized that these assumptions are seldom applicable to any single day or any single rain, and that moisture requirement and the use of the moisture by the plants do vary widely for different rains, but it is believed that the assumptions approximate the average condition over a period of time. When the average daily moisture requirement has been determined, or assumed, each day of the growing season in which the available moisture is less than the requirement is counted as a dry day, and the amount of deficiency for that day is calculated as the difference between required and available soil moisture. The irrigation need in any year is the sum of the daily deficiencies in the growing season. The benefits to be obtained from supplemental irrigation in any locality would be in relation to the amount that the average annual irrigation need exceeds a minimum to be determined empirically.

Illustrative of this method of determining irrigation need are the following data and computations relating to Michigan:

The average annual precipitation in Michigan exceeds 25 in. In part of the state it exceeds 35 in. The average for April 1 to September 30 ranges from 15 to 21 in, according to locality. In all parts of the state, both annual and seasonal averages are sufficient to produce satisfactory crops; yet in some parts, at least, farmers are deriving profit from irrigation.

The growing season for determining irrigation need in any locality has been taken as beginning 15 days after the

TABLE 1. COMPUTATION OF MOISTURE DEFICIENCY (IRRIGATION NEED) AT HASTINGS, MICHIGAN, FOR THE LAST 22 DAYS OF AUGUST 1919

Date 1919 Aug	Rain-fall, in	Equivalent daily increments to moisture supply from each rainfall, in							Total storage, in	Daily deficiency, in
1	0.00									
2	0.00									
3	0.48	.048								
4	1.12	.048	.112							
5		.048	.112							
6		.048	.112							
7		.048	.112							
8		.048	.112							
9		.048	.112							
10		.048	.112						.160	
11		.048	.112						.160	
12		.048	.112						.160	
13	0.72		.112	.072					.184	
14				.072					.072	.028
15	0.33			.072	.033				.105	
16				.072	.033				.105	
17	0.19			.072	.033	.019			.124	
18				.072	.033	.019			.124	
19				.072	.033	.019			.124	
20				.072	.033	.019			.124	
21				.072	.033	.019			.124	
22				.072	.033	.019			.124	
23					.033	.019			.052	.048
24					.033	.019			.052	.048
25	0.05					.019	.005		.024	.076
26						.019	.005		.024	.076
27							.005		.005	.095
28							.005		.005	.095
29	0.36						.005	.036	.041	.059
30							.005	.036	.041	.059
31							.005	.036	.041	.059

3.25—total rainfall for the month

Total deficiency (irrigation need) for the last 22 days 0.643

Average daily deficiency for the 10 dry days 0.064

average date of last killing frost in spring and ending 15 days before the average date of first killing frost in autumn. The basic crop need has been assumed as 1.00 in in 10 days, or 0.10-in depth of water in each day of the growing season. The belief is accepted that rains of more than 1.00 in in any 24 hr do not provide for more than a 10-day period, and that the amount above 1.00 in is lost as surface runoff or as percolation below the root zone. Lesser rains are assumed to be used through the 10-day period at a daily rate of one-tenth of the resulting moisture, rather than at 0.10 in per day for the first part of the period and nothing for the last part. For example, a 0.75-in rain occurring in one day would be used at 0.075 in per day for 10 days rather than at 0.10 in for 7½ days. Each day in which the available moisture is less than 0.10 in is considered a dry day, and the degree of drought or moisture deficiency is determined by difference. If the 0.75-in rain was the only moisture available during that 10-day period, each of the ten days would be counted as dry, and the daily moisture deficiency would be 0.025 in. If the moisture available on any day is 0.099 in, the deficiency would only be 0.001 in, but the day would be counted dry, although the deficiency would have only an inconsequential effect on the irrigation need.

The method of calculating moisture deficiency for a given period is illustrated in Table 1, using precipitation records for August 1919 at Hastings. Each day's rain is distributed separately, and the moisture available on any day amounts to one-tenth of all rain falling in that and the preceding 9 days. The table shows that in the last 22 days of that month there were two dry periods, one of 1 day, August 14, and one of 9 days, August 23 to 31. (In order to obtain the deficiency for the first 9 days in August, it would be necessary to have the rainfall records for the last 9 days in July.)

TABLE 2. COMPUTATION OF MOISTURE DEFICIENCY (IRRIGATION NEED) AT NEWBERRY, MICHIGAN, FOR THE LAST 22 DAYS OF AUGUST 1919

Date 1919 Aug	Rain-fall, in	Equivalent daily increments to moisture supply from each rainfall, in										Total storage, in	Daily deficiency, in
1	0.00												
2	.00												
3	.00												
4	.00												
5	.00												
6	.00												
7	.15	.015											
8		.015											
9		.015											
10		.015										.015	.085
11		.015										.015	.085
12		.015										.015	.085
13	.78	.015	.078									.093	.007
14	.13	.015	.078	.013								.106	
15	.01	.015	.078	.013	.001							.107	
16		.015	.078	.013	.001							.107	
17	.75		.078	.013	.001	.075						.167	
18	.14		.078	.013	.001	.075	.014					.181	
19			.078	.013	.001	.075	.014					.181	
20			.078	.013	.001	.075	.014					.181	
21	.47		.078	.013	.001	.075	.014	.047				.228	
22			.078	.013	.001	.075	.014	.047				.228	
23	.52			.013	.001	.075	.014	.047	.052			.202	
24					.001	.075	.014	.047	.052			.189	
25						.075	.014	.047	.052			.188	
26						.075	.014	.047	.052			.188	
27							.014	.047	.052			.113	
28								.047	.052			.099	.001
29	.24							.047	.052	.024		.123	
30	.10							.047	.052	.024	.010	.133	
31									.052	.024	.010	.036	.014

3.29—total rainfall for month

Total deficiency (irrigation need) for last 22 days .277

Average daily deficiency for the 6 dry days .046

TABLE 3. AVERAGE SEASONAL IRRIGATION NEED IN CERTAIN LOCALITIES IN MICHIGAN

Locality	Average number of dry days per season	Average daily deficiency, in	Average irrigation need, in
Alma	76.4	0.058	4.4
Alpena	75.4	0.060	4.5
Battle Creek	76.9	0.061	4.7
Big Rapids	67.1	0.059	4.0
Detroit	86.0	0.060	5.2
Escanaba	70.3	0.054	3.8
Flint	75.1	0.060	4.5
Grand Haven	92.3	0.063	5.8
Grand Rapids	87.1	0.061	5.3
Houghton	46.8	0.055	2.6
Port Huron	86.9	0.060	5.2
Saginaw	87.8	0.060	5.3

A different distribution that may occur with a comparable amount of rainfall, and the resulting different moisture deficiency, are shown in Table 2 for the same period, at Newberry. The total rainfall at Newberry for that month was 3.29 in and that at Hastings was 3.25 in. Owing to the differences in distribution, the irrigation need for the period was noticeably different, 0.28 in for Newberry and 0.64 for Hastings.

Carried through the irrigation season and over a period of years, computations as illustrated determine the seasonal moisture deficiency or irrigation need. This need, so computed for certain representative localities in Michigan, is shown in Table 3. All the figures in that table are based on precipitation records of 30 years.

The accompanying map of Michigan shows the irrigation need in the different parts of the state, calculated as described. The figures show the depth of water in inches that, on the average, should be supplied to the soil by irrigation in each growing season to maintain 0.10 in available every day. It indicates, for instance, that at Lansing 4.5 in is necessary, while at Newberry only about 2.8 in is required. Although 0.10 in per day may not be the best value for the basic need, and other values undoubtedly would cause some changes in relative locations of lines of equal need, it would seem that for many practical purposes the figures are approximately comparable, so that a figure 5.0 represents a normal irrigation need roughly double that indicated as 2.5, and similarly for other comparisons.

The variations that have occurred from year to year in three localities in Michigan are shown in Table 4. At Houghton the irrigation need is rather small, averaging but 2.6 in per year; at Big Rapids it is greater, 4.0 in; at Grand Haven it is 5.8 in, approaching the maximum in the state.

The data on which this presentation is based were compiled by the Division of Drainage, Soil Conservation Service (formerly of the Bureau of Agricultural Engineering) in cooperation with the Weather Bureau and the Works Progress Administration.

TABLE 4. IRRIGATION NEED EACH YEAR AT SELECTED STATIONS IN MICHIGAN

	Houghton			Big Rapids			Grand Haven		
Year	Dry periods	Dry days	Seasonal deficiency, in	Dry periods	Dry days	Seasonal deficiency, in	Dry periods	Dry days	Seasonal deficiency, in
1906	3	37	1.9	8	69	3.0	6	102	6.5
7	3	39	2.3	6	66	2.2	10	68	2.9
8	5	37	2.0	5	69	4.6	5	93	5.3
9	2	32	1.8	4	79	4.0	6	79	5.4
1910	3	38	2.6	4	79	4.3	6	103	6.1
11	3	28	1.1	3	87	5.1	4	91	5.7
12	4	19	1.2	7	56	2.7	4	99	5.0
13	3	32	1.8	4	48	3.3	7	110	6.6
14	4	25	0.7	5	41	2.3	5	77	5.6
15	5	82	4.1	4	63	3.7	8	61	3.1
16	5	46	2.7	2	79	5.1	6	63	4.9
17	8	77	3.3	8	49	2.3	6	77	5.5
18	2	74	4.7	3	76	5.8	5	106	7.2
19	4	38	1.8	4	75	4.3	4	114	8.6
1920	3	40	2.3	6	51	3.2	4	113	8.0
21	3	39	2.0	6	50	3.1	7	91	5.4
22	5	36	1.9	4	70	4.0	8	81	5.9
23	4	91	4.8	4	62	3.8	6	97	5.3
24	6	86	4.3	5	66	3.5	9	79	3.6
25	7	91	4.6	3	77	4.5	6	96	4.9
26	6	55	3.4	4	75	3.9	6	75	4.7
27	3	21	1.3	3	76	5.6	5	94	5.6
28	7	71	3.8	6	57	2.9	9	80	4.5
29	3	42	2.1	6	74	5.6	4	116	8.0
1930	3	43	3.3	5	77	5.2	1	141	9.2
31	2	58	2.8	4	73	4.3	5	87	6.8
32	3	15	1.2	5	69	3.2	6	110	7.3
33	3	34	1.5	5	69	4.8	5	77	5.3
34	1	54	4.3	5	64	4.6	4	113	6.4
1935	4	26	1.4	6	67	3.6	7	75	5.3
Averages		46.9	2.6		67.1	4.0		92.3	5.8

The Mechanization of a Southern Plantation

(Continued from page 213)

were particularly adapted to the culture of corn, so this has not been a feed crop with us for years. The average yield for corn in Mississippi is well under 20 bu per acre and we have an average of 35 bu for sagrain over a long period. Sagrain also has the advantage over corn in that it can be harvested mechanically. It has been only recently that corn pickers have been used with any degree of success in the delta. The harvesting time for sagrain is not as desirable as some other crops that can also be harvested with power equipment. We are, therefore, eliminating this crop from our program, in favor of oats and barley. These crops require no cultivation, are harvested at a more convenient time, are more easily harvested, and also give greater yields. Last year we averaged 65 bu of oats per acre on 400 acres. As we plan to sell most of these two crops as seed, we have provided a recleaner in our seed warehouse.

In order that we might realize the most from our crops, we are also selling purebred cotton seed. By ginning only our own cotton, we can keep the strain pure. Inspections by the state enable us to sell wilt-free seed. In our seed warehouse we have delinting machines and a machine for treatment with Cerasan. Such equipment as this, properly used, yields good returns on the investment.

For several years we have been buying cattle and feeding them out on feed that we have raised, and processed as needed on a large roughage mill. We believe that this may be a partial answer to our problem of idle cotton acres. We have sown 600 acres to permanent pasture with several varieties of clover, Dallas grass, and winter rye. We plan to continue this operation as long as it is profitable. So far we have tried no hogs and do not expect to.

We feel that we have successfully solved the mechanical problems incident to power operations. We are operating at a profit for all our crops. Our plantation is well improved and we are not through. Our tenants are satisfied and making money. Our main problem now is utilization of idle cotton acres to the best advantage. We are trying in every way possible to make these acres pay and believe that it is a problem that the southern planter can and will solve in a satisfactory manner.

Electric Light for Insect and Bacteria Control

IT IS apparent that the two objects, insect and bacteria control, are not at all related. The former depends upon the attractiveness to phototropic insects of radiation in the visible portion of the spectrum, while the latter depends upon the lethal effect of the shortwave radiation in the invisible ultraviolet portion of the spectrum.

A great deal of data has already been accumulated and published on the former by such research workers as Hermes in California and Hienton at Purdue. They have established very definitely the fact that the blue end of the spectrum has the greatest drawing power, and the red end the least. It appears, therefore, that light sources combining those two are the most effective. The Type H-4 100-watt capillary type mercury arc is such a source.

One interesting experiment was conducted by Houser at the Ohio Agricultural Experiment Station. Believing that the high intensity of daylight was at least partially responsible for the inactivity of certain insects during the day, tests were conducted to see if sufficient intensity of artificial light at night would also keep insects inactive. The new high-intensity, 1000-watt water-cooled mercury arc lamp, emitting 65,000 lumens, was set up in a corn field together with 3000 watts of incandescent lighting. The results were negative.

It would seem, therefore, that the problem has advanced to the stage where the economics of the use of different sources and different makes of electric insect traps is the next most important thing to study.

It would seem to us that the time is about right for the U. S. Department of Agriculture to coordinate the work of individual research workers and undertake an investigation to solve the remaining problems in this field.

Regarding the problem of the control of bacteria by germicidal radiation, there is already available basic data on the amount of energy and length of exposure required to kill the test organism, B-Coli, under different conditions of temperature and humidity, both on dry and moist surfaces, and when suspended in air. These data were included in the Committee's report for 1938-39[1].

Quite a number of installations of germicidal lamps have been made by the two leading manufacturers of such lamps, and considerable publicity has been given to results obtained. This has led to a rather popular idea that germicidal radiation is a panacea for all bactericidal problems. Such is far from fact. One of the leading drawbacks to the use of 2537A (Angstrom units) radiation for sterilization purposes is the fact that such radiation has little penetrating ability. This immediately rules out its use for such purposes, for example, as complete sterilization of clothing and many liquids containing solid material in suspension. The surface sterilization of fruits, nuts, etc., may be possible, but involves complicated methods of irradiating the entire surface of each individual piece. Efforts are continuing to adapt the new sources of germicidal radiation to the sterilization of milk. The fact that these sources emit very much less ozone, less heat, and are much less costly than the older sources of shortwave ultraviolet eliminates some of the causes of failure in previous attempts to sterilize milk and does hold out some possibility for eventual success in that field.

There has been considerable interest stirred up by advertisements of an infrared lamp designed to kill insects on animals, plants, and clothing. A careful study of its possibilities was made at Ohio State University. The net conclusions were that while it is possible to kill fleas, mealy bugs, red spiders, moths, and their larvae, etc., by infrared radiation, it is not a very practical way to do it. The reason is that the difference in temperature between that necessary to kill the insects and that which will injure the host by scorching is so small that it is difficult to accomplish one and avoid the other.

Presented before the Rural Electric Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 7, 1939, as a progress report of the A.S.A.E. Committee on Electric Light for Insect and Bacteria Control—G. E. Henderson, B. D. Moses, C. C. Pink, and L. C. Porter (chairman).

[1]Developments in germicidal lamps. L. C. Porter, Agr. Engr. Vol. 20, No. 11 (November 1939).

Engineering Aspects of Farm Planning

(Continued from page 214)

meal without loss of efficiency, simply because we now think of the complete farm rather than the individual field units.

The acreage limitation of cash crops and the conservation payment program of the national government have enabled the conservationist to stress proper land use with excellent results.

Farm power and machinery should play an important part in future farm planning work. The judicious use of power to facilitate greater production per worker is, according to many authorities, the answer to the problem of low income in the South. It is the problem of the agricultural engineer to make sound recommendations concerning equipment and to devise new machinery as needs develop. Incidentally, ten southern states have a total of 135,000 farm tractors. Farm planning must consider proper power and equipment.

Rural electrification offers a fertile field to the farm planner. Although hardly connected to the original theme of proper land use, electricity opens the way toward reducing time-consuming operations to a minimum, thereby releasing labor for more productive enterprises. The farm planner should make electricity a profit maker rather than a profit taker. Rapid extension of rural electrification lines has made this phase of agricultural engineering a pertinent factor in planning a better living for the rural population.

Farm structures interest the planner mainly from the standpoint of adequacy. Does the farmer have sufficient housing and storage to care for his needs? What repairs and changes can be afforded by the farmer for continued use of the buildings now in existence? In many cases this is as far as the planner may go, because of the cost involved. Usually a very limited amount of capital is available for construction purposes. Nevertheless buildings are continuously repaired or replaced entirely, and it is often necessary to work to an end over a period of years. It is the agricultural engineer's place to see that the buildings which are constructed and the repairs which are made fit the needs of the farmer in the best possible manner. Greater service and efficiency in farm structures should be the keynote.

We may see from this brief sketch of farm planning work that the agricultural engineer has a real opportunity for service. The cooperation of men in many fields of endeavor will be required to provide the answers to the problems of agriculture. The value of the agricultural engineer, therefore, lies in his ability to be of service and to cooperate.

Results of Research in Corn Storage

By H. J. Barre
MEMBER A.S.A.E.

THIS PAPER discusses some phases of the storage of both ear and shelled corn, particularly as to structural and ventilation requirements. Some of the findings of recent corn storage investigations, and a brief discussion of problems needing further study are also included.

Although the storage of ear corn on the farm has been practiced for years, the problems connected therewith became more fully appreciated when recommendations for proper storage were to be formulated in connection with the loan provisions of the Agricultural Adjustment Act. New factors including early picking and the growing of later maturing varieties of hybrid corn in areas of shorter growing seasons have aggravated the problem. The merits of the various ventilating features of different types of cribs and types of ventilators still are not well understood.

Not until the fall of 1938 had the storage of dry shelled corn in tight bins been tried on an extensive scale. Many who had had experience with storage in tight bins felt that difficulties would be experienced with the beginning of warm weather in the spring, during the germination period.

In order to obtain information on the various phases of corn storage, studies by a number of state agricultural experiment stations throughout the corn belt have been conducted for a number of years, to a limited extent. In 1937 the U. S. Department of Agriculture through its Bureau of Agricultural Engineering and several other bureaus, in cooperation with the Illinois and Iowa agricultural experiment stations, inaugurated experimental studies at field stations at Urbana, Ill., and Ames, Iowa. A Bankhead-Jones project was organized a year later at the request of the Agricultural Adjustment Administration, in an attempt to find what types of cribs and what storage practices are most successful in conditioning and maintaining quality of corn stored on farms. Agencies cooperating included the Weather Bureau, Agriculture Adjustment Administration, Bureaus of Plant Industry, Agricultural Economics, and Agricultural Chemistry and Engineering, and the agricultural experiment stations in Minnesota, Indiana, Illinois, and Iowa.

At the field stations, observations have been made on the performance of different types of cribs with various ventilation features. Those at Urbana are mounted on wheels to permit weighing in order to determine the loss in moisture content of the corn. In addition to observations in a large combined crib and granary at Ames, which was divided into various isolated sections to represent certain types of construction, several steel cribs loaned by manufacturers have been erected at the agricultural engineering research farm and filled with ear corn to determine which features have merit in drying of corn.

In the fall of 1938, ear corn from the 1937 crop in nearly 300 cribs was inspected. Samples of corn were obtained by the use of improved sampling probes developed in cooperation with the manufacturer. These samples were examined for moisture content, damaged kernels, and other grade factors. The survey covered counties in Iowa, Minnesota, and Indiana in which storage difficulties had been experienced.

Later in the fall an inspection of different types of cribs was continued in 11 counties located in representative areas in Indiana, Illinois, Minnesota, and Iowa. The inspection included 194 cribs with 1938 ear corn, 25 with 1937 ear corn, and 20 bins with 1937 shelled corn. Samples were obtained at intervals of about every six weeks from certain representative portions of each crib and bin. Grade determinations were made on all samples and in addition, fat acidity, germination, and kernel damage determinations have been made on selected samples.

With the storage of large amounts of shelled corn in steel bins by the Commodity Credit Corporation, the condition and temperature of corn in these bins is being observed periodically in a number of counties in each of the states named above.

Since the problem of storing ear corn is largely one of reducing the excess moisture to make it safe for subsequent storage as either ear or shelled corn, maximum ventilation

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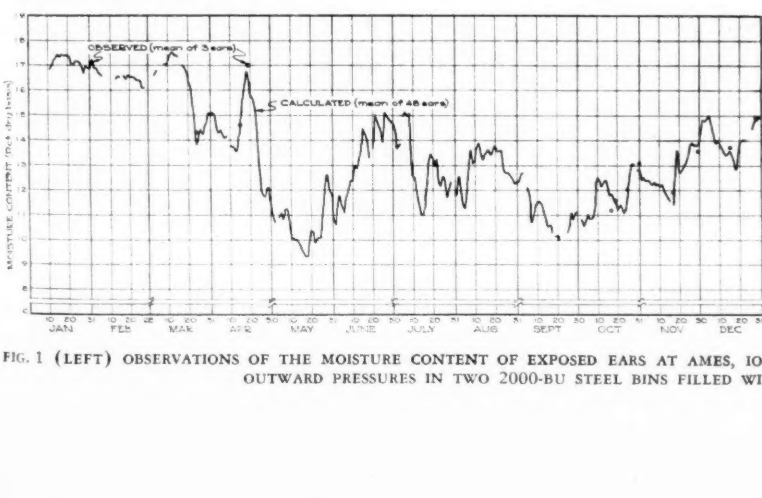

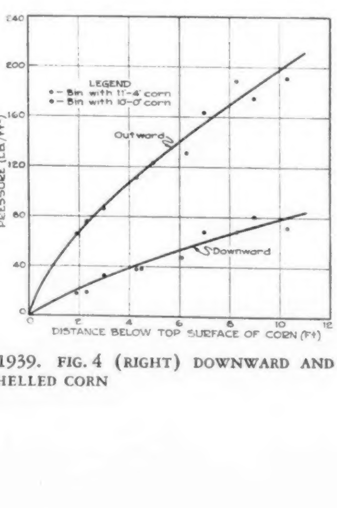

FIG. 1 (LEFT) OBSERVATIONS OF THE MOISTURE CONTENT OF EXPOSED EARS AT AMES, IOWA, 1939. FIG. 4 (RIGHT) DOWNWARD AND OUTWARD PRESSURES IN TWO 2000-BU STEEL BINS FILLED WITH SHELLED CORN

is essential to permit drying at every opportunity when the weather is favorable. It is often cribbed at a moisture content higher than 20 per cent in northern parts of the corn belt. In the colder areas in the corn belt, most of the drying takes place in the spring months. Some drying may also take place in the fall if the weather is warm and otherwise favorable. Very little drying will take place, if any, during the winter months. In fact, corn may take up moisture during these months if the fall is drier than usual.

One is impressed by the need for ventilation when the amount of moisture to be removed from ear corn is considered. For example, in order to reduce the moisture content of a bushel of ear corn from 20 to 13 per cent, a total of nearly 9 lb of moisture, almost one-half of which is in the cobs, must be removed. Hence, in the drying of 1000 bu of ear corn from 20 to 13 per cent, about $4\frac{1}{2}$ tons or over 1000 gal of moisture must be removed. In this respect the storage of ear corn differs radically from that of other grains such as wheat, where ordinarily the moisture reduction necessary to make it safe for storage is only 1 to 2 lb or a few per cent per bushel.

STORAGE AND DRYING OF EAR CORN

Before proceeding to discuss the various crib characteristics which contribute to ventilation it might be well to consider the rate of drying of high-moisture ear corn which could be expected under conditions of maximum ventilation. Observations of weights of ears fully exposed to air in a shelter at both Ames and Urbana[1]*, showed that they lose moisture from five to ten times as fast as ear corn in a crib 8 ft wide. The large difference is primarily in the amount of ventilation. If the same air conditions about each ear in a crib could be maintained as that of the exposed ears, they should dry just as fast as the fully exposed ears. Only by a free air movement in all parts of the crib can this condition be approached.

Fig. 1 shows the moisture content of a group of 48 ears exposed to air in a shelter at Ames for a period of about 10 mo beginning in January 1939. These observed moistures are of interest and value in indicating in general the moisture content to which corn may be expected to dry in a crib for this locality at different times during the year. In other words, they show the limitations imposed by weather on the moisture content. Another important item not shown by this graph is the rate at which the ears will approach the equilibrium moisture content, that is, where the ears as a whole are in equilibrium with the moisture of the air. While space does not permit going further into this discussion, the fact is that the rate at which the ears change in moisture content is much more rapid in summer than in winter. The magnitude of the much larger daily fluctuations during the summer is somewhat of an indication of the greater rate of change in warm weather.

The most important dimension of a crib in promoting ventilation is its width. Experiments with cribs of different widths[1] have shown that corn in a crib 6 ft wide will dry more rapidly than that in a crib 8 ft wide, and the corn in the latter will dry more rapidly than that in a crib 10 ft wide. The additional resistance provided by the thicker mass of corn, to the movement of air through it, accounts in all probability for the slower rate of drying in the wider cribs.

In view of the above, it is apparent why the practice of storing high-moisture corn in a driveway is particularly objectionable. The crib shown in Fig. 2, with corn stored in the full length of the driveway, is virtually a crib 27 ft in width, rather than one of about 7 or 8 ft wide as it should be. The ventilation through the corn in the outer cribs, as well as that in the driveway, is impaired, and unless the moisture content is much lower than usual at the time it is placed in storage, spoilage is likely to occur, even if ventilators are used in the corn in the driveway.

Certain maximum widths of cribs[2] are recommended for different localities in the corn belt because of the maturity of the corn and the prevailing weather conditions during the first six months of storage. Temperatures and humidity of the air, sunshine, amount of wind, and average date of killing frost all have a bearing as to the amount of ventilation needed and determine the width of crib to use.

The height to which the wall should be slatted is somewhat of a question. Experiments with cribs[1] having walls slatted one-fourth, one-half, and full height above the floor showed that the last type is desirable for promoting rapid drying. The amount of spoilage in these was also less. In the crib slatted one-fourth the height, the damage was considerably greater in the upper half. There appears to be no merit, in single cribs of moderate height, in extending the tight siding down farther than a few feet below the eaves, to prevent snow from blowing on top of the corn after it has settled.

The ventilation of cribs with either a tight wall or an enclosed lean-to shed on one side is considerably impaired. There is much less opportunity for air to move through the corn than in a crib open on both sides.

Exposure of cribs to prevailing drying winds is important. The double crib in Fig. 3, partly protected and shaded by the grove of trees, is an illustration of inadequate exposure of the crib to the prevailing winds and the sun. This condition, combined with the fact that the doors were kept closed during the spring, was likely responsible for grade 4 corn in one crib and sample grade in the other, although the moisture content in early December was only 19 per cent.

The results of experiments with ventilators indicate they are not as effective as ordinarily believed, although they have been recommended generally to improve ventilation in case the corn is high in moisture content or the crib is too wide. What types of ventilators are most effective remains to be shown by further investigation.

STORAGE OF SHELLED CORN

As indicated above, the storage of shelled corn differs radically from that of ear corn. Ear corn will dry a good deal if properly cribbed, while shelled corn will dry little, if any, in a tight bin, and therefore must be dry when stored. A moisture content of not more than 13 to $13\frac{1}{2}$ per cent is required for safe storage of shelled corn.

Since dry shelled corn with less than 13 to $13\frac{1}{2}$ per cent moisture will not heat, unless badly infested with insects, there is no occasion for ventilation, except where it might aid in maintaining cooler temperatures of the corn. Ventilation is undesirable under the roof in winter as the surface layer of corn will actually take up moisture from the air. Hence roof ventilators and other openings should be closed in winter. This will not only aid in preventing the taking up of moisture, but will also prevent the possibility of snow blowing in.

The storage of damp corn, as well as that of damp wheat, requires some means of ventilation to remove the moisture and the excessive heat generated by the corn through respiration. Since heating is not likely to present a problem in cold weather, it is possible to store shelled corn of a relatively high moisture content for a limited time.

*Superscript figures refer to literature cited at the end of Mr. Barre's paper.

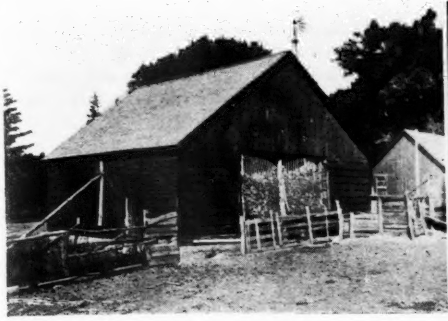
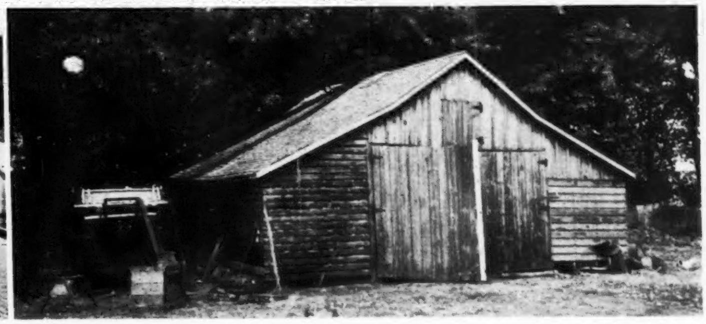

FIG. 2 (LEFT) THE STORAGE IN THE DRIVEWAY OF CORN HAVING ONLY MODERATELY HIGH MOISTURE CONTENT IS CONTRARY TO GOOD STORAGE PRACTICE. THE VENTILATION OF THE CORN IN THE CRIBS ON EACH SIDE IS CONSIDERABLY IMPAIRED. FIG. 3 (RIGHT) THE PROTECTION OF THIS CRIB FROM BOTH WIND AND SUNSHINE BY THE TREES AND CLOSED DOORS TO THE DRIVEWAY WAS LIKELY RESPONSIBLE FOR SPOILED CORN IN THIS CRIB

The problems and limitations in connection with the storage of damp corn need further investigation.

Although the walls of most types of cribs are relatively open and there is some opportunity for rain water and snow to get to the corn next to the wall, the most essential part of a crib, in so far as weathertightness is concerned, is a tight roof. A survey of cribs in September 1938, showed that the roofs of an appreciable number of cribs were in poor condition. Probings of the corn in such cribs often revealed moldy and at times wet kernels, a condition not to be expected at that time of the year.

It is desirable to prevent snow from blowing onto the top of the corn. This may be accomplished by extending tight siding below the eaves to a point which will be below the level of the corn after settling. Since snow will also drift in through the slatted walls and sometimes several feet into the corn, it is desirable to locate the cribs somewhat protected from north and west winds. For this reason cribs in northern areas are usually located on the south side of a driveway and grain bins, sheds, and other units are located on the north side. Since corn usually takes up moisture during the winter, and because of the hazard of drifting snow, there is some merit in having the crib incorporated in a building which can be closed during unfavorable weather. Observations of cribs so located showed the corn to be from 2 to 3 per cent drier than that in exposed cribs.

Experience during the first year of loans on shelled corn showed that the entrance of rain water and snow was practically the major cause of storage difficulties. Even with unusually dry grain, a bad roof leak or two will cause some of the grain to spoil. The spoiled portion tends also to make the adjacent grain musty and may cause it to heat. As indicated above, all openings including those of the ventilator, should be closed during the winter to avoid any possible entry of snow. Although a roof may be rain-tight, it is often more difficult to make it snow-tight.

Cribs filled with ear corn are subjected to loads and pressures much greater than ordinarily supposed. Observations made by McCalmont and Ashby[3] several years ago show that in a crib 8 ft wide, without cross ties or braces, the proportion of the total weight of corn carried by the floor at various depths is as follows:

Depth, ft	Proportion, per cent
8	72
12	68
16	64
24	52

In cribs with cross braces, less weight is carried on the floor, since an appreciable part of the weight is carried on the braces.

The outward and downward pressures on the wall with and without cross braces in a crib 8 ft in width were found in the above investigations to be as follows:

Depth below surface, ft	Without cross braces, lb/ft² Outward	Without cross braces, lb/ft² Downward	With cross braces, lb/ft² Outward	With cross braces, lb/ft² Downward
8	62	41	58	38
12	79	50	70	45
16	91	58	81	50
20	100	61	88	51

The outward pressures in cribs 10 and 12 ft wide at the same depths were estimated to be 25 and 50 per cent greater, respectively, than those given in the above table. In the 8-ft crib with 24 ft of corn, about one-third of the total weight is carried by the cross braces, which were spaced from 5 to 6 ft apart.

Although the ear corn settled after filling, there was a relatively small increase in the weight on the braces after filling. The distribution of the total weight of the 24 ft of ear corn in the crib with cross braces was about as follows: 45 per cent carried by the floor, 20 per cent by the wall through friction, and 35 per cent on the braces. For example, the outward and downward pressures which have to be carried by one stud in a crib 14 ft high with studs spaced 2 ft apart and cross braces 4 ft apart, are 1400 and 950 lb, respectively. In addition, the studs to which the braces are fastened have to support a vertical load from the brace of about 2000 lb. The cross brace is called upon to resist an outward pull of about 2000 lb.

Field observations and experience have shown that unless cribs are designed to withstand these rather large loads and pressures with a reasonable degree of safety, failures are sure to occur, with the result that the life of the building as well as the period of usefulness is considerably impaired. In cribs other than the circular type, cross bracing which is an economical method of resisting the outward pressures, has always presented a problem, largely because of the weight the braces must carry in addition to resisting the outward pressures. In frame cribs the cross brace of three 1x12-in boards has been observed to be satisfactory where the total depth of the corn is not more than 16 ft. This type has maximum strength for carrying a vertical load, in addition to a much larger nailing surface, than can be obtained, for example, by a 2x6-in piece. These are ordinarily spaced 4 ft apart.

Cross ties of wire or steel rods are usually undesirable, because the weight of the ear corn will break them, or they

will draw the wall in at points where they are anchored. Frequently the stud is broken or cut into by wire because of insufficient bearing surface. Ties do not provide the necessary cross bracing of the building when the cribs are empty and the overhead bins are loaded.

Inasmuch as no pressure measurements had been conducted on shelled corn, pressure panels were installed in the doors of two 2000-bu steel bins at Webster City, Iowa, to determine the pressures exerted by shelled corn. These bins were filled with corn of a moisture content of about 11 per cent. One bin was filled to a depth of about 11 ft and the other 10 ft, containing about 2300 and 2000 bu, respectively.

The preliminary observations showed that at a depth of 10 ft the outward pressure is about 210 lb per sq ft, while the downward pressure at this depth is about 80 lb per sq ft (Fig. 4). In other words, the outward pressures at 10 ft would produce a tension of about 1900 lb in a one-foot strip of wall of the bin 18 ft in diameter. From an average value of the downward pressure of about 40 lb per sq ft, the bin wall 10 ft 8 in high carries a total load of about 24,100 lb, or almost 19 per cent of the total weight of the corn. By comparing these outward pressures with those of ear corn, it will be noted that the pressure of shelled corn is about three times that of ear corn. Hence, additional bracing or tying is needed in cribs which are to be used for storing shelled corn. Pressures from ordinary wheat appear to be somewhat less.

FACTORS INFLUENCING DATE OF PICKING

In view of the fact that picking with a machine is more satisfactory earlier in the season and losses in the field are likely to be less, the tendency is to start picking early. However, these advantages may be more than offset by the better quality of corn stored after it has become drier. A few observations made to date indicate that high-moisture corn placed in storage is likely to be damaged by mold in a few weeks after cribbing, providing warm weather prevails. High temperatures stimulate the activity of microorganisms, and apparently they are active even though the weather may be unusually favorable for drying.

In the case of one of the cribs with 1937 corn which contained an unusual amount of damage, the picking was started as early as September 20 and finished by October 1. The objective of this particular farmer in starting early was to complete picking before his neighbor would start, as he had borrowed the picker.

This fall a few well-ventilated cribs were filled experimentally during the latter part of September in order to obtain high-moisture corn. After a few weeks of storage, an appreciable amount of mold was noted, and the damage rapidly increased during the warm weather, although the weather was unusually dry. Damage to the corn under the filling spout was considerably greater where there was a considerable collection of husks and shelled corn. It should perhaps be mentioned that these conditions were observed in cribs as narrow as 6½ ft in width and otherwise provided with good ventilation features.

There is less opportunity for damage to take place when damp corn is cribbed in cold weather, as microorganisms producing mold are relatively inactive at low temperatures. There is also opportunity for high-moisture corn to lose some moisture during the winter before warm weather occurs.

Rat damage in varying degrees was evident in nearly every crib inspected in the surveys. The extent of damage in many cribs was a good deal more than expected. It was rather unusual to probe a crib and not find some rat stools in each of the individual probings. The upper layers of corn were frequently found to be infested, as well as the lower portions. Rats had frequently eaten holes in the roofs to permit them to obtain water more readily. Some farms were conspicuously free from them, indicating that rats can be controlled by proper measures.

Frequently a crib badly infested with rats and one practically with no evidence of rat damage were found on the same farm. The infested crib encouraged the harboring of rats, because the floor was built close to the ground and because there was ample opportunity for rats to get into the crib. The floor of the other crib was higher above the ground. Creosote-treated timbers and treated wood floors appeared to be effective in preventing damage.

SUBJECTS FOR FURTHER STUDY

Before concluding this discussion it might be well to mention a few phases of corn storage which need further attention.

1 The requirements of cribs as to ventilation in areas where high-moisture corn occurs and where weather is less favorable for drying are not well known. More definite answers to such questions as the following should be obtained: What are the relative merits of floor and wall ventilation, of roof and crib ventilators? At what maximum moisture contents can grains be conditioned satisfactorily under the different prevailing weather conditions? What are the merits of natural, controlled, and mechanical ventilation?

2 The relation of weather to the successful storage of ear corn in particular has not been given the attention it deserves. The limitations as to the moisture content to which corn will dry under natural ventilation and the rate at which they approach this moisture content are governed by the prevailing weather and should be evaluated for various areas. It is rather doubtful if, under extreme conditions of immature corn and unfavorable weather for drying, storage difficulties can be avoided altogether, even in the better ventilated structures.

3 Although there is available a limited amount of data as to the pressures of shelled corn and other grains, the behavior of these pressures under certain conditions is not known. For example, does the downward pressure by friction continue to exist on the wall of a steel bin when placed on a gravel fill and the wall is permitted to settle? What stresses are introduced in bins when emptied from the bottom at one side or a corner?

4 Experiences with control of insects by fumigation in storage of shelled corn are limited. The frequency of fumigation to insure against infestations should be evaluated for shelled corn and for different areas in the corn belt.

5 In view of the importance of the storage of shelled corn, the changes in the soundness of the stored corn, if appreciable during storage for 2 or 3 yr, should be observed. Does this vary with the moisture content and quality? Is the loss of dry matter appreciable? Does it vary with different areas?

LITERATURE CITED

[1]Report of the chief of the Bureau of Agricultural Engineering, 1938. Annual Reports of the U. S. Department of Agriculture.

[2]Corn storage in the ever-normal granary. Agricultural Adjustment Administration, U. S. Department of Agriculture, Bul. 38-Corn-2. 1938.

[3]McCalmont, J. R., and Ashby, Wallace. Pressures and loads of ear corn in cribs. Agr. Engr. 15:123-128. 1934.

Preliminary Analyses of Runoff Data from the Edwardsville Project

By W. W. Horner

AS A part of its program for securing adequate runoff data, the U. S. Soil Conservation Service has installed equipment for the collecting of hydrologic data for three small watersheds and a terraced area near Edwardsville, Ill. The three watersheds are respectively known as W-I, W-II, and W-IV, and have areas of 27, 50, and 290 acres, respectively. The small W-I watershed (Fig. 1) is entirely in cultivation, while the others include portions of pasture and woodland.

The area is adequately covered by recording rain gages and the runoff is measured over broad-crested, V-notch weirs equipped with waterstage recorders. Runoff studies on the Edwardsville project are conducted jointly by research and technical operations of the Soil Conservation Service in cooperation with the Illinois agricultural experiment station. The technical phases of the work are carried out by R. P. Weeber of the Edwardsville project under the direction of the Hydrologic Division which is represented by Neal E. Minshall, line project leader for the runoff studies in Region V. The equipment was put in operation during February and March 1938 and complete records from that date are available.

Through the courtesy of Dr. M. L. Nichols, assistant chief of the Soil Conservation Service in charge of research, and C. E. Ramser, chief of the hydrologic division, Leonard Lloyd, under a graduate fellowship in hydrology at Washington University, was permitted to undertake the analyses of the basic data accumulated.

The objective of this analysis was the determination of infiltration capacity for each of the watersheds for at least one year of the record. Mr. Lloyd has completed the analysis of the smaller W-I watershed, and has done extensive work on the others. His work as a whole will be reported on at a later date. The purpose of this paper is merely to present some preliminary observations as to the character of the data, the methods employed, and the value of the results that are being secured.

Basic data collected gives a complete picture of rainfall occurrence and of runoff for each precipitation period throughout the record. The data collection equipment has apparently been quite satisfactory and has been well managed; and the basic data are unusually accurate and satisfactory to work with.

These data have been reduced to graphical form for each precipitation period, and in this form shows a diagram of rainfall intensity, the mass curve of rainfall, the hydrograph of runoff, and the mass curve of runoff. Runoff data are corrected for pondage behind the weirs, and are representative of inflow into the small ponds above each weir.

As stated above, the objective of the present analysis is the determination of infiltration capacity values for as much of the precipitation periods as the data will permit. The ultimate objective of this analysis is to make available such infiltration capacity values for estimating the flood flow from other storm precipitation periods. To the extent that these values become generally available, it will be possible to avoid entirely the older technique in which runoff was estimated by applying a coefficient of runoff to mean precipitation rate for a chosen duration of rainfall. In other words, excess rainfall will be determined by subtracting infiltration capacity rate during the period of excess rainfall from precipitation intensity rate. Excess rainfall in turn may be taken as substantially equivalent to mass runoff, and runoff rates may be determined by an application of the unit hydrograph or channel storage methods[1].

In the past, in the absence of an adequate understanding of the mechanics of infiltration, those factors which control infiltration during and subsequent to a storm period could not be separately isolated, and infiltration has largely been thought of in terms of monthly, seasonal, and annual values.

The conception of "infiltration capacity" introduced by Horton and the improved knowledge of the mechanics of

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[1]This does not refer to the unit hydrograph in the form originally developed by L. K. Sherman, but more nearly to a distribution graph which would be applied to the distribution of excess rainfall only.

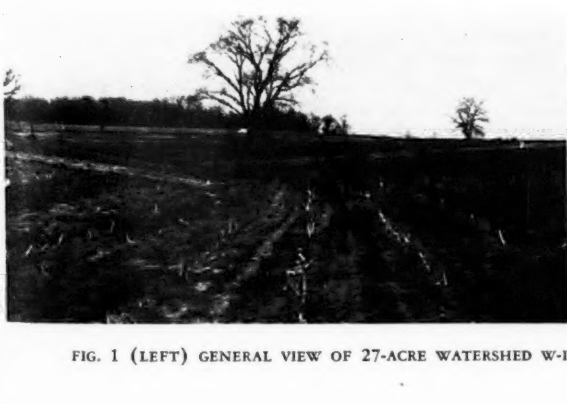

FIG. 1 (LEFT) GENERAL VIEW OF 27-ACRE WATERSHED W-I. FIG. 2 (RIGHT) WEIR AND RECORDER FOR WATERSHED W-I

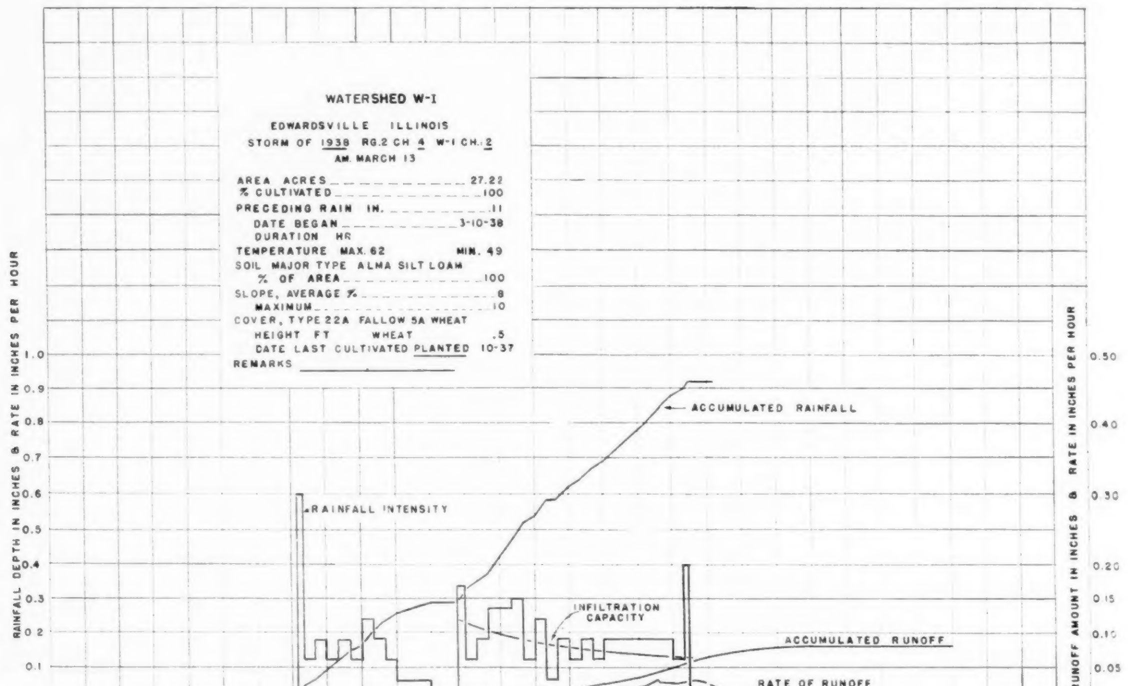

FIG. 3 RAINFALL INTENSITY, ACCUMULATED RAINFALL, RATE OF RUNOFF, ACCUMULATED RUNOFF, AND INFILTRATION CAPACITY CURVES FOR WATERSHED W-I FOR ONE STORM PERIOD IN MARCH 1938

infiltration which has appeared out of the research programs of the Department of Agriculture have completely altered this situation.

As originally defined by Horton, infiltration capacity is "the maximum rate at which the soil, when in a given condition, can absorb falling rain." It is a significant physical property of the soil. It is a rate value of the same character as precipitation intensity. When subtracted from precipitation intensity for a specific time period, the resulting difference is the rate of production of excess rainfall. The summation of such differences evaluates total excess rainfall for any period chosen. Excess rainfall in turn for most drainage basins may be taken as sensibly equivalent to volume of surface runoff.

These relationships permit the determination of infiltration capacity from rainfall and runoff data, and the application may be reversed in order to estimate the volume of runoff or stream flow from any storm for which the pattern of precipitation intensity is known, when such a storm occurs on an area for which infiltration capacity values may be available.

It must be recognized that infiltration capacity is a limiting rate at which infiltration may occur for any given condition of the soil. Surface runoff occurs whenever precipitation intensity exceeds this rate. As a result of other studies, it has been recognized that infiltration capacity, being related to soil condition, changes as the condition of the soil changes; and it has been generally known that it will have high values after a prolonged period in which no precipitation occurs. During a period of continued precipitation, infiltration capacity will be initially high, but will reduce as the precipitation continues and ultimately become substantially constant.

The factors which control this change during a precipitation period are still somewhat a matter of controversy. Horton has stated as a result of his experience, that the reduction of infiltration capacity during a precipitation period is due largely to a change in the soil surface structure, such as may be brought about by rain impact, the closing of sun checks and the infiltration of fines into the coarser pores of the surface. Undoubtedly for many soils these changes may represent the principal control of infiltration capacity reduction. They are well illustrated by the findings in a paper by Duley and Kelly[2]. There is, however, good evidence that for many soils the reduction in infiltration capacity is closely related to the satisfaction of soil moisture deficiency. It seems quite probable that the causative factors may be different for different soils and covers, and in any particular case may combine in different ways to produce the lowering of infiltration capacity values.

Regardless of the causes, about which we have yet much to learn, the fact remains that these values can be determined experimentally for any specific soil and cover; and the variation throughout a precipitation period, that is, the march of infiltration capacity values, may be readily determined and the results may be ultimately correlated against other controlling variables.

The hydrologic data available from the small watersheds, such as those at Edwardsville, offer unusually satisfactory information for the determination of these values.

The method used in analyzing the Edwardsville data is substantially one of balancing excess rainfall against runoff for storm periods, or for readily divisible parts of a storm period. It assumes that runoff is equal to the excess rainfall and proceeds to relate each divisible portion of the runoff hydrograph to the rainfall producing it. The hydrographs for these small watersheds show unusual response

[2]Effect of soil type, slope, and surface conditions on intake of water. Nebr. Agr. Exp. Sta. Research Bul. 112, May, 1939.

to changes in precipitation intensity, and it is surprising to what extent sections of the hydrograph may be matched up with the sections of the precipitation diagram.

Stated as above, this method would involve charging all losses to infiltration. It is obvious, however, that allowance must be made for that part of the loss during excess rainfall which is involved in interception and in depression storage. For the purpose of this analysis, these losses were grouped together and designated "retention." Obviously that part of the retention which is due to interception, will occur out of the initial rainfall whether or not this occurs at excess rates. That part due to the depression storage can only occur after precipitation intensity exceeds infiltration capacity. For the purpose of this analysis, the depression storage thus filled in the beginning of excess rainfall is considered as remaining filled at the end of excess rainfall, and a loss value representative of it is carried through the computations.

In order to describe in somewhat more detail the application of this method, the diagram for precipitation of March 13, 1938, is shown on Figs. 3 and 4. This was, in reality, two separate storms, separated by approximately seven hours, and each of the storms was in turn divided into two major parts. The characters of the hydrographs were such that each of the parts could again be subdivided for analysis.

The method used initially was one of cut-and-try, as it is not possible to determine in the beginning the ordinate values of infiltration capacity, and therefore impossible to determine in detail those parts of the precipitation period for which the opportunity for infiltration at capacity rates existed. A comparison, however, of the rainfall diagram with the hydrograph gives a quick indication of the general trend of infiltration capacity values. For example, no runoff occurred prior to 7:00 a.m.; therefore, the infiltration capacity values prior to that time must have been in excess of 0.12 in. No runoff occurred out of the high peak at the beginning of the rain, but this peak had to satisfy the interception section of retention, and infiltration capacity may have been as low as 0.2 in per hour at the beginning.

However, runoff did occur out of the peak at 7:00 a.m., so that infiltration capacity rate at this time was low enough to develop something more than excess rainfall required for depression storage. It was therefore obviously below 0.30 in. A marked rise of the hydrograph at about 7:30 indicates clearly that appreciable excess rainfall existed between 7:20 and 7:50, and the infiltration capacity value is obviously on the order of 0.20 in at that time. A similar rise after 9:00 o'clock indicates that the infiltration capacity value at that time was appreciably below 0.18 in. A preliminary sketching in of the infiltration capacity rates on this basis indicates the periods of precipitation from which excess rainfall could occur and for which excess rainfall may be balanced against runoff.

The hydrograph was then broken up into parts by applying recession curves beyond each small peak in the hydrograph, thus segregating the runoff which must have resulted out of a particular part of the precipitation, and the infiltration capacity curve is finally adjusted so that the excess rainfall and runoff are in balance for each section.

For the period between 6:54 and 10:15, the finally adjusted values of infiltration capacity have been joined by the line shown on Fig. 3. This is the result of actual calculation as to five points, and very good indications of limiting values at other points. A similar application to the afternoon rain as shown on Fig. 4 produced four points on the curve.

Comparison of these two figures develops a well-determined trend of infiltration capacity reduction during precipitation from 7:00 to 10:00 a.m., a very definite and

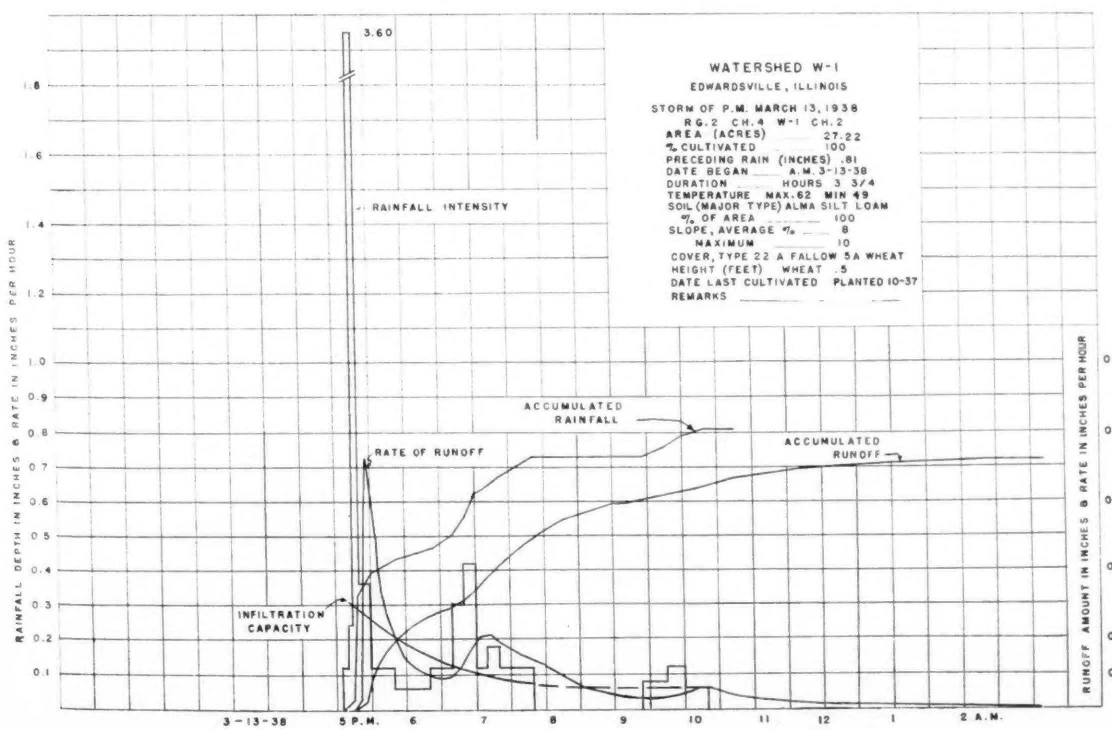

FIG. 4 CURVES FOR STORM FOLLOWING 7 HR AFTER THAT COVERED BY CURVES OF FIG. 3, SAME WATERSHED

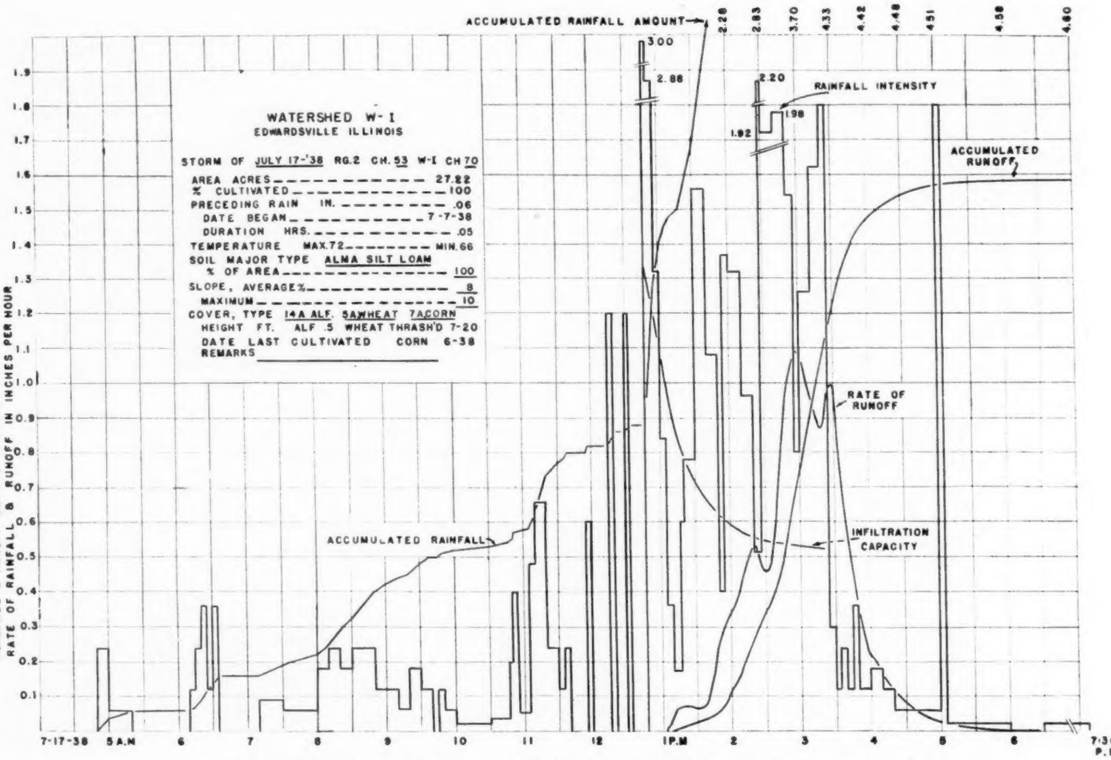

FIG. 5 CURVES FOR A STORM IN JULY 1938 ON THE SAME WATERSHED AS IN FIG. 3

considerable recovery of infiltration capacity between 10:00 a.m. and 5:00 p.m. and a steady reduction thereafter to a final value for this storm period of approximately 0.06 in per hour.

As an illustration of the very different values existing during the summer season, the storm of July 17, 1938, is shown on Fig. 5, indicating that the infiltration capacity at the beginning of this storm must have been considerably in excess of 2 in per hour, and after 12 hr of nearly continuous precipitation is reduced to slightly over 0.5 in per hour.

In passing, the important effect which storm pattern has on runoff and runoff rates should be noted from these graphs. For example, for the storm of July 17, it is entirely possible that, if the 1 in of rainfall which occurred after 3:00 p.m. had occurred in the early part of the storm, even at the same intensity rates, it would have produced little or no runoff. This obviously indicates the futility of attempting to apply mean infiltration capacity rates to any such storm period as this. The mean infiltration capacity rate during this storm period was probably in excess of 1 in per hour. If a line were laid across the rainfall diagram at 1 in per hour, the calculated excess rainfall would be so utterly different from that which occurred as to be completely unrepresentative of rainfall runoff relationships.

As stated in the beginning, the immediate objective of the present analysis is the production of infiltration capacity curves of the type shown. A study of the curves which have been developed for the storms of the first year's record, indicates that these will show a very definite seasonal change in infiltration capacity, and that envelope curves may be produced for the full year which will be representative of values likely to exist at the beginning of the precipitation period, and of the minimum values which may be expected after a period of considerable precipitation.

While the record of any one year will develop an insufficient number of examples for a good determination of this characteristic, it appears now that the analysis of a record two or three years in length may be sufficient for the production of values that are definitely and satisfactorily usable for the prediction of runoff from a storm of any specific pattern at any particular time in the year. Such curves, of course, will be related to average conditions existing during the various months of the year, in so far as the years of record are representative of average conditions, and may later be subject to further refinement by correlating the values to soil moisture conditions in the particular months or to antecedent precipitation.

There is rather good evidence that, for the soils at the Edwardsville project, the reduction in infiltration capacity during a precipitation period may be correlated primarily to increase in the soil moisture. Horton, in analyzing the result of Neal's work[3], worked out the equations of reduction of infiltration capacity with time. It should be noted, however, that those experiments involved uniform and continuing excess rainfall throughout the period of each run. In view of the fact that, in nature, excess rainfall rarely occurs continually throughout a storm period, it would be desirable to attempt to correlate the march of infiltration capacity with some other controlling factor. It would certainly be interesting to attempt to do so with respect to initial soil moisture and mass infiltration throughout the storm period. It is to be hoped that such a study can be carried out before the analysis of the Edwardsville data is finally completed.

[3]The Effect of the Degree of Slope and Rainfall Characteristics on Runoff and Soil Erosion. Mo. Agr. Exp. Sta. Research Bul. 280. April, 1938.

Farm Appraisals

THIS report is intended to show (1) the human need and increasing demand for sound and dependable farm appraisals, (2) the want of more basic appraisal knowledge, and (3) the need for men in the appraisal profession who are technically trained, have conservative judgment, and are willing to serve in accordance with high ethical standards.

It is not necessary to search far into the past to find glaring examples of unsound and unstable land values. When farm debt and taxes were low, soils fresh and productive, new and undeveloped lands still available and the market for farm products appeared to be unlimited, the trend of land value was generally upward and was expected to vary only with the demand. Like the price of common stocks or wheat and cattle, the basis of all farm value during that period was marketableness, and the need for sound appraisals reflecting intrinsic values of more or less permanence was generally not recognized.

It has now been discovered that many lands have to some extent worn out and their fertility must be rebuilt or the land abandoned altogether. New problems in marketing of farm products are being faced and operating costs are changing because of the use of modern machinery, higher labor costs, soil treatment, and higher taxes. Also, the farmer's standard of living has changed. These factors and many others make it necessary to discard the old basis of land value and to replace it with new methods designed on the basis of modern experience and trends in agriculture.

The extreme high land prices of the war period were no more justified than the extreme low prices that followed twelve or fifteen years later. Farmers, investors, and farm credit organizations suffered immense losses as a result of these extremes. It is true that fluctuations in land sale prices can probably not be prevented when there is a rise or fall in the general economic condition of the country. However, had a reliable system for sound basic appraisals been available to credit agencies and the public during the last two or three decades, many thousands of farmers might have saved their homes from foreclosure.

Aside from the major field of appraisals for farm credit purposes, there is a universal need for an appraisal service that farmers and others can rely upon when sound values are required to be known. Before a farmer purchases land he should be able to obtain a reliable appraisal and analysis of the farm's intrinsic qualities, earning capacity, and value. Such appraisal would not only serve to guide him in an economically favorable investment but might also assist him in selecting a farm of the type and characteristics best suited to his needs. Farmers who desire to operate in accordance with modern farm management programs, should know the sound value of their farm plant. In order to be successful, it is just as important for a farmer to know the value of his farm and equipment as it is for the merchant to know the value of his business. There can be no doubt that untold numbers of farmers who have failed or who have made no progress, must attribute their lack of success to an original farm investment entirely in excess of its real intrinsic worth. Most farmers, no doubt, are aware that an overvalued farm can not succeed, but relatively few farmers are able to determine a sound value of their enterprise.

Reliable appraisals and sound values are needed in connection with the division of estates, taxation, and condemnation purposes. In the organization of drainage or irrigation enterprises, a detailed appraisal should unquestionably be required. It may be well to call attention here to the large number of special improvement districts in which the feasibility was based primarily upon the acre-feet of water available, or the runoff obtained, without regard to the probable sound value of the land so improved. Many of such districts have been economic failures from the beginning and have resulted in staggering losses both to farmers and to investors in district securities.

APPRAISAL METHODS REQUIRE FURTHER STUDY

During the last 8 or 10 years much study and thought has been given to the development of an appraisal system or procedure that would reflect a more or less permanent or normal value not subject to all the whims of buyers and sellers or other periodic market fluctuations. This led to the conclusion that the intrinsic characteristics of the farm itself as an agricultural unit, and its capacity to perform consistently with typical or average management under normal and average conditions might constitute a sound basis for such normal or reasonably permanent value. The principal factor influencing this performance is the land's agricultural earning ability, which in turn is affected by various other factors such as soil, topography, drainage, buildings, location, home, maintenance, taxes, farm product prices, and others. As long as no material change occurs in any of these factors, it is thought the land value should remain reasonably constant. Several appraisal procedures now in use are built upon the "normal earning ability under average conditions" theory. The methods of application differ somewhat and herein lies a field for research and study that should interest agricultural engineers.

The process of farm appraisal can never be made a mechanical one, nor are appraisals reducible to mathematical formulas, graphs, or curves. Every factor is a variable. Direct capitalization of net income is useful, but when used without proper safeguards may lead to an incorrect answer. However, it is believed that some reliance can be placed upon the capitalization process, after more accurate analyses of the farm income and expense, and of the factors that influence the net earnings, are made. It is doubtful if the field of capitalization, or any modified form of the process, has been fully explored. In view of its possibilities, it certainly should not be condemned until it has been further investigated. The process of analytical comparison which is extensively used by one lending agency tends to create a proper balance and consistency between appraisals, but is entirely dependent upon a correctly established datum plane. The reliability of appraisal under this method depends to a great extent upon the sound judgment of seasoned and experienced appraisers and unceasing reviewals.

Although the appraisal procedures now in use have faults and weaknesses, and some of the steps in the analysis are controversial, they also have outstanding qualities of high merit. The accuracy of the value established under any procedure depends in a great measure more upon the care with which the data have been assembled and the judgment used in the analysis than upon the motions re-

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Presented before the Farm Structures Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 6, 1939, as a report of the Committee on Farm Appraisal—A. E. Bachman, A. O. Kay, E. W. Lehmann, C. R. Olson, G. B. Hanson, J. C. Wooley, and F. H. Schreiner (chairman).

quired by the method employed. Regardless of such faults as the several appraisal procedures which attempt to establish a normal or basic value may have, they are believed to be in tune with the right key to sound value. The evolution of farm appraisal theory is not yet complete, and much work needs to be done in the refinement and further improvement of the procedures. Notwithstanding the development that has taken place and the progress that has been made, there yet remains to be worked out a unity of thought on the whole procedure. Many appraisers are still experimenting with this or that method and they are not sure that they know positively what weight or influence each factor has in relation to the whole. These appraisers are trying to accomplish something with tools that have not yet been perfected for the purpose. Very frankly, the opportunity for study of farm appraisal procedure and refinement of method is still unlimited.

FACTORS INFLUENCING FARM VALUES

Among the special subjects related to farm appraisal that need to be studied further as factors of value, are soils and crop yields. It is not enough to know that a farm has a certain acreage of a given soil type, and its productivity index. The appraiser is faced with the very practical problem of translating soil data into crop production data, and the disparity of information suited to that purpose becomes readily apparent when he attempts to solve that problem. Then again, if the appraiser attempts to establish a reasonably permanent value he must go outside of the soil's past production record and look to its present and future trend in producing ability. When one reflects on the vast acreages of eroded hillsides and worn-out lands that once were productive and profitable, it again becomes apparent that some means of measuring the probable deterioration of a given soil must be devised. Productivity ratings are useful and reasonably accurate when comparing the potentiality of one soil type with another, but are often quite worthless in determining the actual production of crops on any given farm field. Depth of soil, the slope, erosive tendency, previous use, and numerous other characteristics affect the crop yield, and much additional information is needed by the appraiser to aid him in making an intelligent determination of present or expected future yields of a given soil area. It is possible that productivity ratings may become more useful if further broken down into subindices for each soil type. The appraiser and soil technician have an opportunity to develop a solution for that problem.

Another phase of appraisal procedure that requires more careful technical consideration is drainage and irrigation and their accompanying financial and economic aspects. Ordinarily, an inspection of a farm and its immediate surroundings fails to reveal flood or drainage hazards that may exist, particularly when supposedly corrected through the medium of a special improvement district. Extensive flood, drainage, and stream flow studies often need to be made of large areas or even whole river valleys, in order to obtain a true picture of the conditions that affect a single farm. Likewise, in irrigation areas, the adequacy of water supply, water rights, and other conditions involve extensive study by the appraiser before he is in position to intelligently analyze a farm in the area. In this connection, the financial condition of any organized drainage, levee, conservancy, or irrigation district that may be involved is also a factor of land value and should be thoroughly analyzed by the appraiser. The appraiser is then confronted with the question as to what to do with the bonded debt of the district or any contingent liability that may exist. One appraisal system in general use endeavors to value all land on a debt-free basis. Any liability incident to district bonds or special assessments is regarded comparable in effect to any other farm mortgage or debt and as having no influence on the normal or basic value. This point is controversial in that some appraisers believe that the annual tax or assessment for bond and interest retirement should be regarded as an annual farm operating expense, thereby reflecting the district's bonded debt into the value of the farm. A great deal may be said on both sides of this question and agricultural engineers will find this an interesting subject for further research.

The appraisal of farm buildings, their maintenance, depreciation, and obsolescence suggest a wide-open field for additional study. Schedules of building values on a square or cubic-foot basis are available and depreciation tables have been prepared, but the appraiser often finds that the computed results are not in proper relationship to the farm value. Buildings on farms have a utility or use value entirely separate and distinct from their replacement or depreciated value, and this use value may vary in different communities or on different type farms. Whether or not the value of certain conveniences of farm homes and farm structures should be regarded as a personal investment without relationship to the farm plant is debatable. It certainly must be admitted that some conveniences add to the farm's earning capacity, but there is no measure by means of which the worth of the conveniences can be determined. Maintenance or repair costs often bear some relationship to the type of farm, its size, and productivity. Closely associated with building depreciation and maintenance is the subject of repair and depreciation of farm equipment. Unquestionably a better method needs to be developed, by means of which greater uniformity in building estimates can be obtained and frequent wide divergence between appraisers avoided.

NORMAL AND FUTURE FARM PRODUCT PRICES

In establishing a normal agricultural or basic farm value, it is necessary to assume a normal or standard price for farm products and a more or less stable cost of labor and other items entering into farm operating expense. While average prices prevailing during the 1909 to 1914 period are often referred to in agricultural statistics as "normal prices", it is evident that recent world and domestic conditions make it appear that the price of some farm products may never again approach this normal level. Cotton is an example which, because of manufactured substitutes and competitive foreign production, has an entirely different market status than during the 1909 to 1914 period. Some other crops are similarly affected. Changes and adjustments in the so-called normal price schedule are necessary. It might even be possible to establish a normal price schedule based on some other premise entirely unrelated to the 1909-1914 period. Any adjustments or schedule that may be adopted must reflect not only the present but also the probable future world economic status of the crop considered.

Once the normal agricultural value or basic value of a farm has been established, auxiliary values may be determined. Farms underlain with valuable mineral or having an unusually good location as a commercial site have an auxiliary value which would in most instances increase the market value over and above the normal agricultural or basic value. It is conceivable that in some instances the auxiliary qualities may outweigh the strictly agricultural qualities of the farm to such an extent that the farm has lost a corresponding portion of its basic value for agricultural purposes. Farms recently *(Continued on page 234)*

Durable Concrete Silo Staves

By Philip W. Manson
MEMBER A.S.A.E.

SILOS of concrete, properly made, will give long and satisfactory service at little or no maintenance cost to the farmer. However, the concrete stave silo is but one of the several kinds giving good service, and it is not the purpose of this article, which deals only with silos made of dry-tamped concrete staves, to advocate the use of concrete silos in preference to those of other types or materials. The desire is to stress the importance of quality when the purchase of a concrete silo is under consideration.

Since 1930, the Agricultural Engineering Division of the University of Minnesota Department of Agriculture at University Farm, St. Paul, has been making extensive studies relative to the durability of concretes and mortars exposed to weak acids, silage juices, and severe weather conditions. The making and testing of about 4,000 commercial concrete silo staves from 30 different silo plants located in Minnesota, Iowa, and Wisconsin, has been done under the supervision of the Division concrete products laboratory.

Transverse Strength. In order to measure the durability of a concrete stave, it is subjected to a series of laboratory tests. First the stave is placed flatwise on two supports 24 in apart, in a machine that applies a load midway between the supports until the stave is broken. This is known as the transverse strength test. The result of such a test is recorded as so many pounds breaking strength per inch of width for a stave thickness of 2½ in. A high transverse strength is one reliable index of a good stave. From laboratory tests it has been found that the more durable staves have a breaking strength of 140 lb, or more, per inch of width.

Absorption. The denser the concrete, the less the pore space therein, and consequently the less fluid it will absorb. Amount of water absorbed, expressed as a percentage of

Paper No. 1819, Scientific Journal Series, Minnesota Agricultural Experiment Station. Based on tests in the laboratory at University Farm, St. Paul, Minn., conducted cooperatively by the Soil Conservation Service of the U. S. Department of Agriculture, the Minnesota Agricultural Experiment Station and the division of drainage and waters of the Minnesota State Department of Conservation, the Bureau of Agricultural Chemistry and Engineering of the U. S. Department of Agriculture contributing toward the making of the silo stave studies.

The author is research instructor, Division of Agricultural Engineering, University of Minnesota, Department of Agriculture.

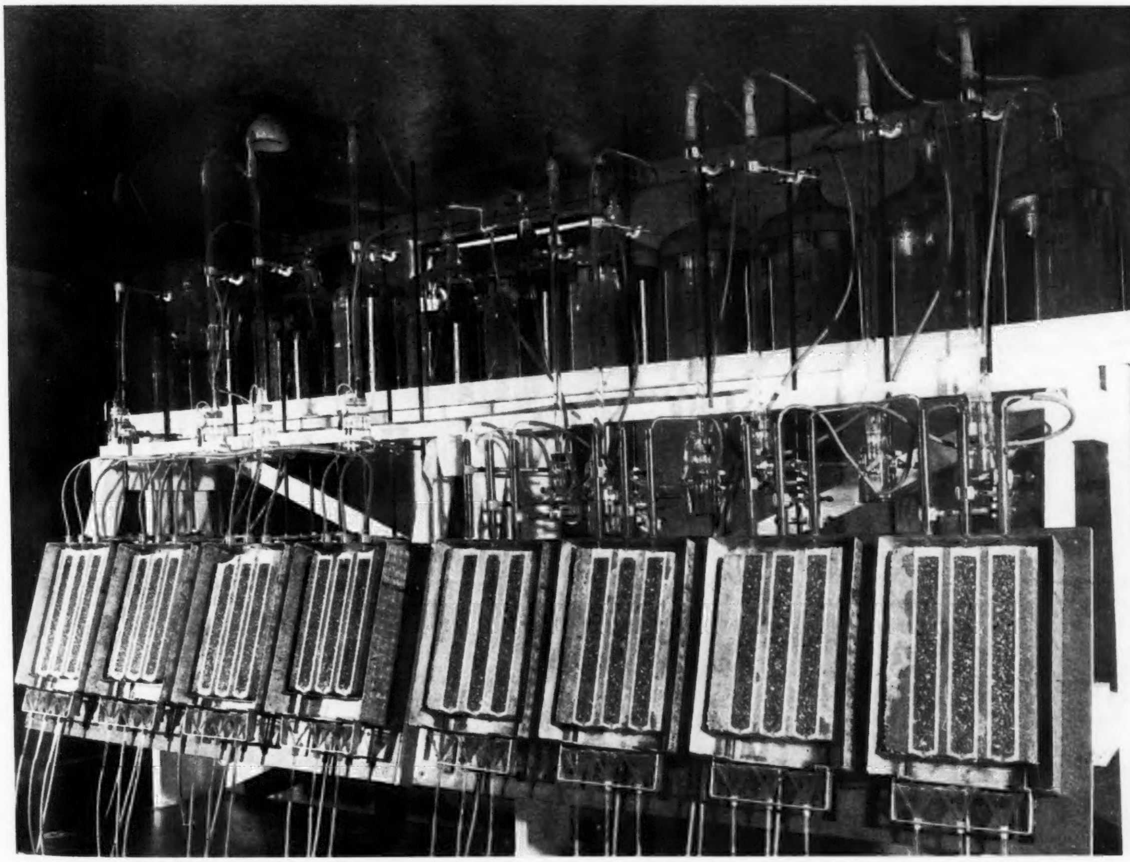


FIG. 1 APPARATUS FOR LABORATORY TESTS OF CONCRETE SILO STAVES EXPOSED TO WEAK ACIDS
The solution is applied to the staves at the upper ends of the channels by a drip method from capillary tubes of glass calibrated to deliver 2 liters of solution in 24 hr. Every 24 hr each channel is cleaned of loosened material by brushing 50 down strokes with a 1-in flat brush of steel wire, the loosened material being caught in filter-lined 6-in funnels and then oven-dried and weighed

the oven-dry weight of the concrete, is the accepted measure of absorption. Conversely, therefore, low absorption is a measure of the density of concrete. Hence, it is another *essential* property of concrete used in silo staves. A silo wall must prevent the passage of air and juices through it if the silage is to keep well. It must also resist the acid action of the silage, as well as the freezing and thawing action of our winters.

The acids encountered are mainly lactic and acetic. They are weak, as acids go, but they will attack concrete. The less these juices are absorbed by a concrete stave, the more durable it will be. It is, therefore, extremely important to obtain dense silo staves.

The absorption test of a concrete stave is made by first thoroughly drying the specimen at a temperature of 240 F (degrees Fahrenheit). After drying it is submerged in water for 10 min, weighed, and then put back into the water and again weighed after 48 hr soaking. The 10-min absorption is a measure of permeability, and the 48-hr absorption is a measure of pore space. The tests show that the highest quality staves will have a 10-min absorption not in excess of 2 per cent, and a 48-hr absorption not in excess of 5.5 per cent. All staves having a 10-min absorption of 2.5 per cent or less, gave satisfactory durability tests under laboratory exposures.

Acid Resistance. An apparatus (Fig. 1) has been devised in the laboratory[1] by means of which it is now possible to measure the relative resistance of different types of concrete staves to the action of weak acids. This test further supports the importance of having concrete of high strength and low absorption, as shown in Fig. 2.

Graphs in Fig. 2 show the relative resistance to 0.1N (normal) mixtures of acetic and lactic acids, of concrete staves manufactured at four plants, as indicated by the accumulated quantity of material loosened by twenty daily brushings. A 0.1N acid solution was made by combining 291 ml (milliliters) of commercial acetic acid (56 per cent) and 240 ml of clear U.S.P. lactic acid (85 per cent) in 54 liters of distilled water. The acidity of this mixture was pH 2.5 at room temperature. These test staves were made under the general supervision of the laboratory and include such variables as richness of mix, aggregate grading, consistency, number of tamps, and curing.

Plotting of the points in Fig. 2 disregards the plant procedure and takes into account only the 10-min absorption, the transverse strength, and the grams of material loosened after 20 days exposure to a 0.1N mixture of acetic and lactic acids. The transverse strength and the 10-min absorption are good indices of stave quality.

The tests in the laboratory, and a few in the field, show that staves testing about 140 lb in transverse strength and having a 10-min absorption of 2.5 per cent or less, are durable under all the exposures that might be expected from ordinary silage on the farm.

It will be noted, from the lower graph in Fig. 2, that the resistance of a stave to acid attack does not increase very rapidly for strengths above 140 lb. From the upper graph in Fig. 2, it is further obvious that the resistance of a stave to acid attack does not increase much for absorptions less than 2 per cent. On the contrary, the resistance decreases rapidly for absorption higher than 2.5 per cent. Staves testing 140 lb or more per inch of width consistently give high durability tests, while those testing below 140 lb have a wide range in acid resistance. Likewise, specimens having an absorption of 2.5 per cent or less will generally give good durability tests, while those testing above 2.5 per cent may range from durable to inferior.

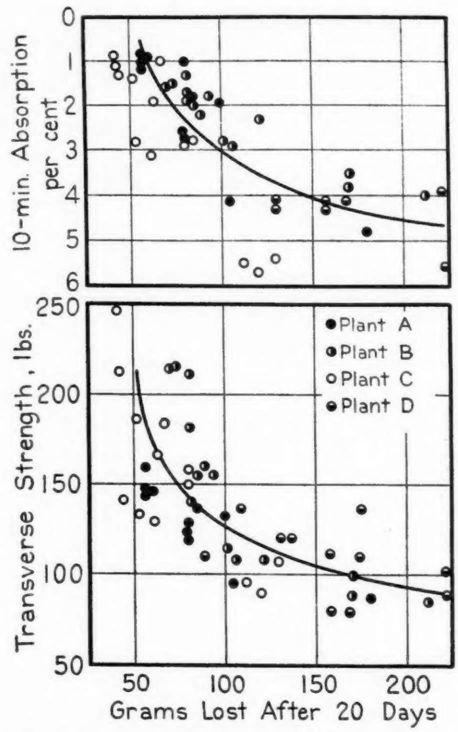


FIG. 2 MATERIAL LOST FROM CONCRETE SILO STAVES OF WIDELY DIFFERING TRANSVERSE STRENGTHS AND 10-MIN ABSORPTIONS

Consequently it may be said, in support of the high quality stave, that, while the requirements of 140 lb transverse strength and a 10-min absorption not in excess of 2.5 per cent may be somewhat rigid, staves of such standards will give assurance of a high quality and durable product.

Freezing and Thawing. At present the freezing and thawing tests have not been completed. The available data indicate results comparable to those found by exposing various qualities of concrete to weak acids. Concrete staves of high transverse strength and low absorption will exhibit a resistance, when exposed to freezing and thawing action, many times that of staves of inferior quality.

SOME ESSENTIALS OF MANUFACTURE

It is difficult, under the processes ordinarily used, to manufacture dry-tamped concrete silo staves of 140-lb transverse strength and low absorption, except by the use of rich mixes. It is also difficult to make more than 7½ to 8 high quality staves from one bag of cement. Making 9 or 10 staves per bag effects a saving of only 5 or 10 dollars per silo. As a consequence, manufacturers in Minnesota and neighboring states, generally, feel that it is good business to make the better stave in spite of the slight extra cost. In practice it has not been feasible to step up the ratio of "buckshot" gravel much above one part gravel to two of sand. A large proportion of coarse material may result in a harshness objectionable in appearance, and a breaking off of some of the edges. However, the rougher looking staves are better, as a rule, than the smooth appearing ones.

Up-to-date manufacturers are checking their aggregates very carefully to make sure that their sand and gravel are of a durable type. *(Continued on page 234)*

[1]Dalton G. Miller, Philip W. Manson, and Charles F. Rogers. Laboratory tests of concrete and mortars exposed to weak acids. AGRICULTURAL ENGINEERING, vol. 20, no. 11, (November 1939).

Transport Wheels for Agricultural Machines

VIII. Soil Penetration Tests as a Means of Predicting Rolling Resistance

By Eugene G. McKibben and Dale O. Hull
FELLOW A.S.A.E. JUNIOR A.S.A.E.

SUMMARY

1 The relation between the penetrations obtained with two penetrometers (Fig. 1) and the rolling resistances for two steel wheels and two pneumatic implement tires (Fig. 2) were investigated for 17 road and field conditions (Table 1).

2 The correlation coefficients obtained for the eight comparisons ranged from 0.92 to 0.98 and in all cases were highly significant statistically (Table 2).

3 The Rototiller penetrometer gave slightly better results than the other instrument used and has the added advantage of being simpler.

4 Graphical methods of using Rototiller penetrometer data to estimate the probable rolling resistance of transport wheels are outlined.

A SIMPLE field test giving a single constant which could be satisfactorily used as a measure of the soil's resistance to the rolling of a transport wheel would be of considerable aid to investigators and designers. With this objective in mind a rather thorough study was made of the relationship between penetration and rolling resistance for two penetrometers and four wheels.

Penetrometers. The two penetrometers used, Iowa[1] and Rototiller[2], are shown in Fig. 1. This figure also shows the Proctor[3] soil plasticity needle, which was later compared with the two penetrometers.

Wheels. Two steel wheels, one 6x28 in and the other 2.5x36-in, and two pneumatic implement tires 6.00-16 and 7.50-28 in, respectively, were used. These wheels, which are shown in Fig. 2, were selected as representative of those most commonly used on agricultural machines. In addition, the 7.50-28-in wheel is the largest which could be tested to capacity with the equipment available.

Road and Field Conditions. Trials were made on seventeen road and field conditions ranging from concrete to loose tilled sand. These test conditions are listed descriptively in Table 1.

Test Results. Correlations between the penetration determinations and the rolling resistance results are given in Table 2. The correlation coefficients were all high, over 0.90, and highly significant statistically in every case. Be-

Journal Paper No. J-760 of the Iowa Agricultural Experiment Station, Project No. 576, in cooperation with the American Society of Agricultural Engineers. Articles I to VII of this series have appeared consecutively in AGRICULTURAL ENGINEERING from November 1939 to May 1940, inclusive.

The authors are, respectively, associate professor of agricultural engineering, and research fellow in agricultural engineering, Iowa State College. (The latter is now automotive engineer, Standard Oil Co.)

[1]Page 349. Res. Bul. 231, Iowa Agr. Exp. Sta. 1938.

[2]Stone, A. A. and Williams, Ira L. Measurement of soil hardness. AGRICULTURAL ENGINEERING 20: 25-26. 1939.

[3]Proctor, R. R. Description of field and laboratory methods. Engineering News-Record 111: 286-289. 1933.

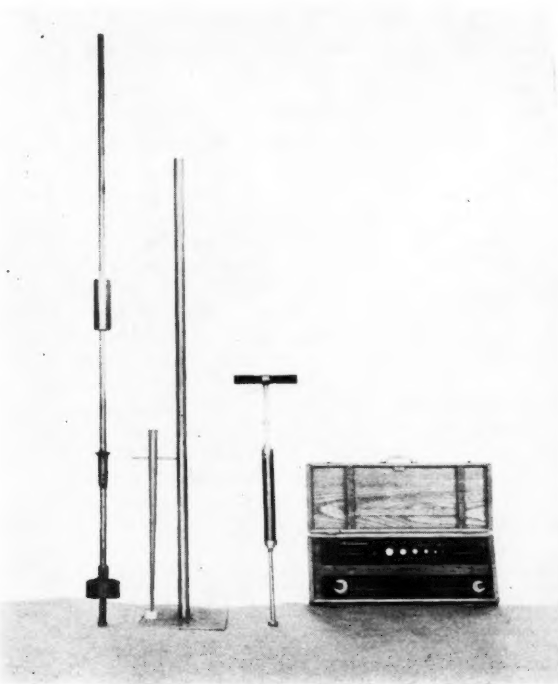
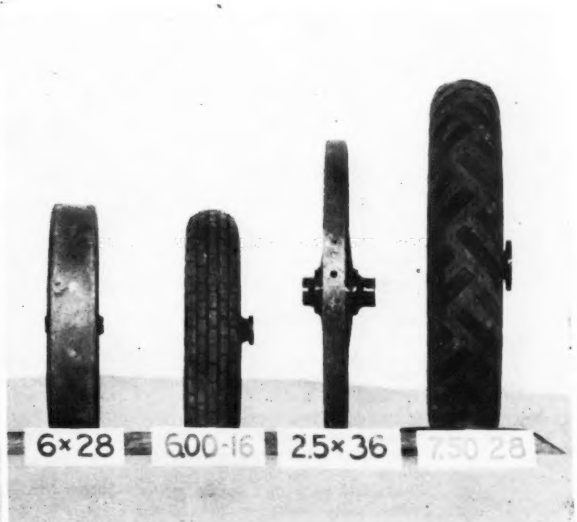


Fig. 1 (Left) Iowa penetrometer, Rototiller penetrometer, and Proctor soil plasticity needle. Fig. 2 (Below) Wheels used to obtain the penetration-rolling resistance data in Fig. 3



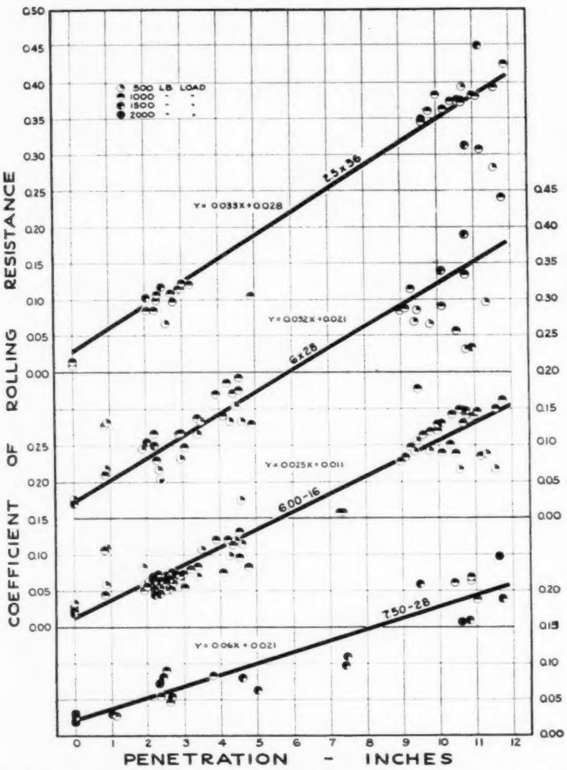


Fig. 3 Relation between penetration of Rototiller penetrometer (Fig. 1) and rolling resistance of 2.5x36 and 6x28-in steel wheels, and 6,00-16 and 7.50-28-in pneumatic tires. Wheels are shown in Fig. 2 and soil conditions are listed in Table 1

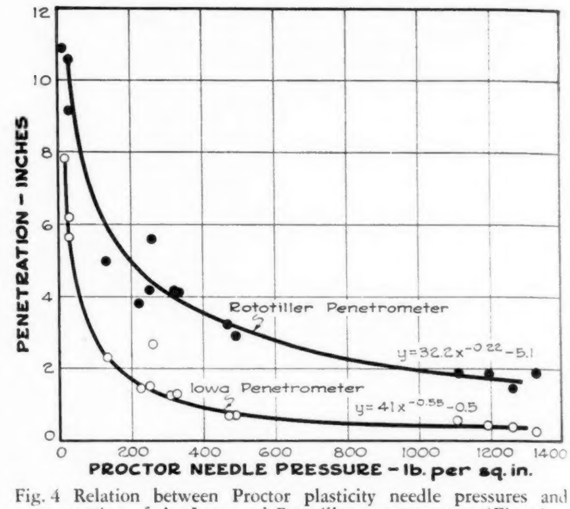


Fig. 4 Relation between Proctor plasticity needle pressures and penetration of the Iowa and Rototiller penetrometers (Fig. 1)

cause the results obtained with the Rototiller penetrometer are slightly better, and because it is a simpler, less expensive instrument which has already attained some acceptance, the data for this instrument only were plotted in Fig. 3. The graphs shown in this figure are plotted from regression equations obtained by the method of least squares.

Proctor Soil Plasticity Needle. Because the Proctor soil plasticity needle has attained considerable acceptance among certain engineering groups, it was compared with the Iowa and Rototiller penetrometers for a number of soil conditions. The results of these comparisons are shown by Fig. 4. This instrument is, however, much more complicated and expensive than either of the penetrometers.

TABLE 1. ROAD AND FIELD CONDITIONS USED TO OBTAIN THE PENETRATION-ROLLING RESISTANCE DATA PLOTTED IN FIG. 3

1 Concrete road
2 Stabilized gravel road
3 Cinder road
4 Frozen ground covered with 4 in of snow
5 Bluegrass pasture
6 Timothy clover meadow
7 Alfalfa meadow, heavy growth
8 Dry alfalfa sod
9 Sweet clover stubble
10 Rye stubble
11 Soybean stubble
12 Corn stubble
13 Cornfield after last cultivation
14 Fall rye seeding
15 Rough fall plowing
16 Freshly tilled loam
17 Loose tilled sand

TABLE 2. CORRELATION BETWEEN PENETRATION AND COEFFICIENT OF ROLLING RESISTANCE FOR TWO PENETROMETERS[a] AND FOUR WHEELS[b]

Wheel[b]	Penetrometer[a]	Number of comparisons[c]	Correlation coefficient[d]	Standard error of estimate[e]
6x28	Iowa	52	0.93	0.034
	Rototiller	52	0.94	0.034
6.00-16	Iowa	126	0.92	0.035
	Rototiller	126	0.92	0.026
2.5x36	Iowa	82	0.98	0.054
	Rototiller	35	0.94	0.050
7.50-28	Iowa	34	0.95	0.083
	Rototiller	34	0.96	0.066

[a]See Fig. 1.
[b]See Fig. 2.
[c]Each comparison is between the mean of five penetrometer determinations and the mean of three 50-ft rolling resistance tests. The pooled standard error of the means of five Rototiller penetrometer determinations varied from 0.13 in for bluegrass pasture to 0.58 in for tilled loam, and for the means of three wheel tests the standard error of the coefficient of rolling resistance varied from 0.002 for concrete to 0.004 for tilled loam.
[d]All correlations are highly significant, statistically.
[e]Of coefficient of rolling resistance.

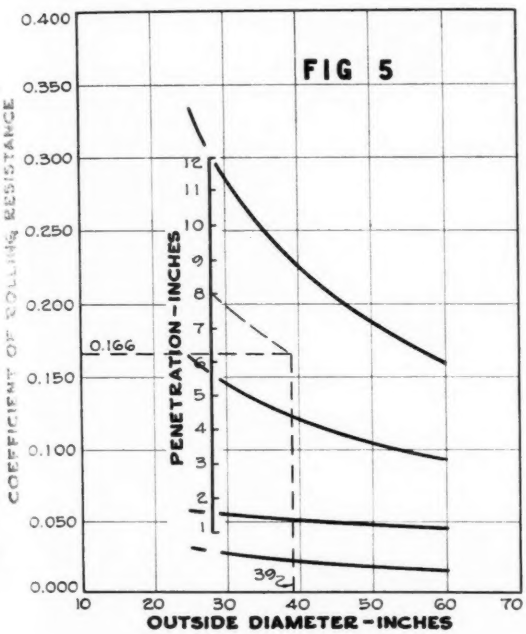
Predicting Rolling Resistance of Pneumatic Tires. By using Fig. 5, an estimate can be obtained for the coefficient of rolling resistance of an individual pneumatic tire operating at 16 lb per sq in on any road or field for which Rototiller penetrometer data is available. This figure was obtained by combining the penetration-rolling resistance data shown in Fig. 3 for the 6.00-16-in tire with the diameter-rolling resistance data shown in Fig. 2 of article IV of this series[4]. Further, by using Fig. 6, similar predictions may be made for inflation pressures other than 16 lb per sq in.

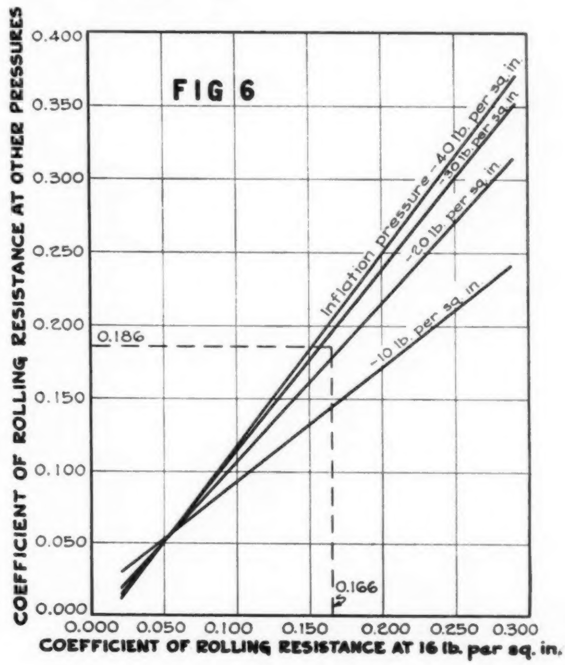
As an illustrative example, the rolling resistance of a 7.50-24-in tire operating at a 24-lb inflation pressure and carrying a 2,000-lb load on a field where the Rototiller penetrometer reading is 8 in would be estimated as follows: The nominal outside diameter of this tire would be 39 in. By using this 39-in diameter and the 8-in penetration to enter the diameter and penetration scales of Fig. 5, an estimate of 0.166 is obtained for the probable coefficient of rolling resistance with an inflation pressure of 16 lb. By

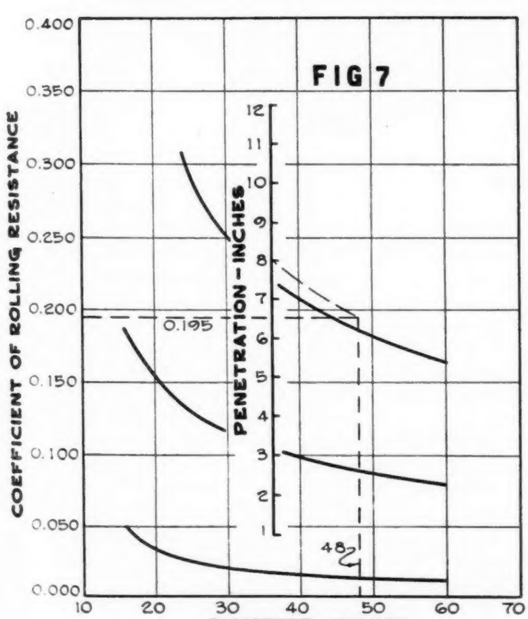
[4]McKibben, Eugene G. and Davidson, J. Brownlee. Transport wheels for agricultural machines: IV. Effect of outside and cross-section diameters on the rolling resistance of pneumatic implement tires. AGRICULTURAL ENGINEERING. 21: 57-50. February 1940.

entering Fig. 6 with this coefficient of 0.166 an estimate of 0.186 is obtained for the probable coefficient of rolling resistance at the higher inflation pressure of 24 lb. Finally, the rolling resistance is estimated at 372 lb by multiplying the 2,000-lb load by the coefficient 0.186.

It must be noted that the results obtained by this plan are, at best, only estimates and that the utility of the method is yet to be determined by general field use. It is also probable that such field use, when and if it occurs, will indicate the need of modifications.







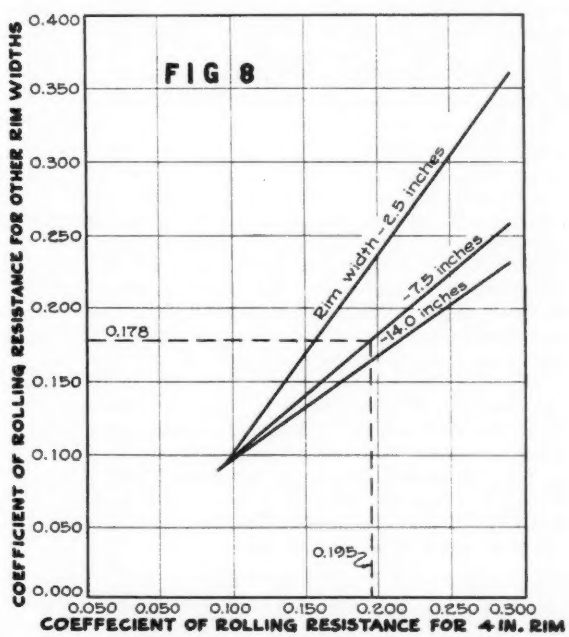


Fig. 5 (Top, left) Relation between penetration of Rototiller penetrometer and coefficients of rolling resistance for pneumatic implement tires of different diameters when inflated to a pressure of 16 lb per sq in. See Fig. 6 for other inflation pressures. Fig. 6 (Top, right) Relation between coefficients of rolling resistance at an inflation pressure of 16 lb per sq in and at pressures of 10, 20, 30, and 40 lb per sq in. See Fig. 5 for estimating the coefficient of rolling resistance at 16 lb per sq in. Fig. 7 (Bottom, left) Relation between penetration of Rototiller penetrometer and coefficients of rolling resistance for steel wheels with 4-in rims. See Fig. 8 for other rim widths. Fig. 8 (Bottom, right) Relation between coefficients of rolling resistance of steel wheels with 4-in rims and similar wheels with 2.5, 7.5, and 14-in rims. See Fig. 7 for estimating the coefficient of rolling resistance of 4-in rims

There are a number of factors such as muddy, sticky field conditions, extreme loads, and abnormal tire cross-section diameters which are probably not adequately considered. For example, the rolling resistance of very narrow tires on loose soils will usually be appreciably higher than the value estimated by the method just outlined.

In spite of these limitations, however, the authors believe that penetration tests offer a practicable means of predicting the approximate rolling resistance of transport wheels on agricultural soils.

Predicting Rolling Resistance of Steel Wheels. By combining the penetration-rolling resistance data shown in Fig. 3 for the 2.5x36-in steel wheel with diameter and rim width-rolling resistance data previously published[5], similar graphs, Figs. 7 and 8, were developed for estimating the rolling resistance of individual steel transport wheels.

The illustrative example shown in these figures is for a 7.5x48-in steel wheel carrying a 2,000-lb load on a field where the Rototiller penetrometer reading is 8 in.

As already stated in connection with Figs. 5 and 6, the results obtained are, at best, only estimates. The graphs of Fig. 8 are especially subject to limitations, and should be applied only where the soil is relatively uniform throughout the layer principally affected by the rolling transport wheel. For example, a surface layer of low supporting ability underlaid by a hard subsurface may nullify or even reverse the effects of increasing the rim width.

[5]McKibben, Eugene G. Some kinematic and dynamic studies of rigid transport wheels for agricultural equipment. Res. Bul. 231, Iowa Agr. Exp. Sta. 1938.

Durable Concrete Silo Staves

(Continued from page 230)

In the manufacture of dry-tamped staves it is necessary to use nonplastic mixes because the forms are stripped immediately after the tamping, and undue deformation follows when the consistency of the mix is too wet. Any deformation in excess of one thirty-second inch on the long edge of the stave is apt to cause trouble when the silo is erected. Therefore, the tendency is to use too dry mixes, although much strength and durability are thus sacrificed. A good mixer man can judge so accurately that the maximum water can be added without getting any appreciable slump.

Plant conditions govern the number of tamps that should be applied to the concrete. Most manufacturers use between 6 and 14 tamps on the concrete and several more blows on the tamper plate. The correct number of tamps to apply can be determined only by making trial batches and varying the number of tamps; and, finally, by having the staves tested to determine which are the best.

Interior Surface Treatment. Some surface treatments may help to protect the interior surface of a silo for a few years, but they will not indefinitely protect staves of poor-quality concrete. It is more effective and reliable procedure to use high-quality concrete in the erection of a silo wall than it is to attempt, later, to protect a wall built of poor materials. If a special interior treatment is to be used, it is better to apply it on a good stave.

CONCLUSIONS

High-quality concrete silo staves are durable. A concrete stave of durable aggregates, testing in transverse strength 140 lb per inch of width, having a 10-min absorption not in excess of 2.5 per cent, and a 48-hr absorption not in excess of 5.5 per cent, should give long, satisfactory service. Many manufacturers are now selling staves of this high quality. The purchase of those of poorer quality is not recommended.

Farm Appraisals

(Continued from page 228)

foreclosed, or about to be foreclosed, or located in communities where many farms are under unwilling ownership, generally carry a stigma of distress or depression, and the sale or recovery value might in such cases be even less than the farm's normal or basic value. The determination of auxiliary values should seldom be difficult but investigations that lie entirely outside of the agricultural field may often be necessary.

TECHNICALLY TRAINED MEN NEEDED

Appraisers, like artists, must possess at least a degree of natural talent for their work. This talent, coupled with training and sound judgment, is the foundation for sound appraisals. There is a difference between knowing land values and being able to arrive at land values by means of sound analysis and reasoning. Under the old system the appraiser generally professed to "know" land values. An analysis of the farm and the things that give it value was of little importance in his method of reaching a conclusion. Modern methods of agriculture, keen competition, high taxes, and small margins of profit make it imperative that the old system of land estimating be abandoned and that values be determined in a more scientific manner. Appraisal service such as is now in use, and will in the future become in more demand, requires technicians of superior specialized training and knowledge who are willing to serve in accordance with high ethical standards and professional dignity. If agricultural engineers expect to serve agriculture in their fullest capacity, they must go beyond the problems of structural design and engineering research, and interest themselves in the economic justification of the gadgets they have created for agriculture. They must temper their profession with a knowledge of farm living, general farm production and farm financial problems. It is doubtful if there is any specialized field of agricultural service other than farm appraisal in which farm economics are brought in closer contact with the engineering aspect of agriculture.

In Europe, particularly in England, valuation specialists have been professionalized for many years. In several other European countries land valuations are generally conducted through the civil service. The productive capacity of a farm is recognized as basic in European appraisals. In the United States, except for a few outstanding exceptions, farm appraisals are generally made in accordance with the notion of the individual or organization making the appraisal. Land appraisers in some departments of government service must qualify through the classified civil service. The U. S. Civil Service Commission makes no attempt to seek or develop appraisers trained or experienced in any particular method or system of appraisal. The appraisal system, if any, to be used depends entirely upon the policy of the establishment employing the appraiser. At least one government unit has adopted a system based on the "normal value under average conditions" principle. The present civil service qualifying requirements were to some extent designed to qualify men who were at the time already in government service and a revision might now be desirable.

An appraisal method or system built on the normal or basic value theory is being used by some independent appraisers, and one or two life insurance companies have adopted this system.

Considering the magnitude of the field for reliable appraisal service and the high type of trained men needed to render that service, it would seem that agricultural engineers, because of their specialized training, should consider farm appraisals a major responsibility.

NEWS

Bibliography of Hydrology Published

THE fourth annual edition of the Bibliography of Hydrology prepared by members of the American Geophysical Union will soon be issued. This bibliography covers as completely as possible all publications in the field of hydrology issued in 1939 in the United States, including government publications, and consists of abstracts of all references.

The United States Bibliography of Hydrology was originally established in cooperation with the International Association of Scientific Hydrology with headquarters in Paris, France, in its effort to publish an annual world bibliography. This year the United States alone of all the countries represented in the International Association is in a position to continue the work with undiminished vigor. The financial aid of the International Association has been withdrawn on account of present world conditions but the American Geophysical Union will continue this publication on a self-supporting basis in view of the very rapid progress being made in hydrology and the need for prompt dissemination of data and research in this field.

Abstracts are prepared under the supervision of chairmen of the research committees of the Section of Hydrology of the American Geophysical Union which is organized to function in the following specialized fields: Rainfall and hydrometeorology, runoff and floods, underground waters, snow, glaciers, physical limnology, evaporation and transpiration, infiltration, physics of soil moisture, dynamics of streams, chemistry of natural waters.

The bibliography will contain some 400 entries and will be issued in June. Nonmembers may subscribe by advance payment of 50 cents per copy to the American Geophysical Union, 5241 Broad Branch Road, N.W., Washington, D. C.

Appraisal Conference at Winnipeg

APPRAISAL will be the featured subject at the summer conference of the American Society of Farm Managers and Rural Appraisers, and the Appraisal Institute of Canada, to be held at Winnipeg, Manitoba, Canada, June 25 to 27. Those attending this conference are also invited to attend a joint conference of the Canadian Society of Technical Agriculturists and the Canadian Seed Growers Association at Winnipeg the previous week.

Some of the appraisal subjects to be presented and discussed include "The Need For, and Proper Basis of, A Sound Appraisal System," "The Underlying Principles of and Necessary Materials for Sound Rural Appraisal," "Farm Management in Mortgage Practice and Its Relation to Sound Appraisal Practice," "The Appraisal of Raw and Undeveloped Land," "Progress in Appraisal Technique and Practice in Western Canada," and "The Development of Appraisal Technique and Practices in Connection with the System of the American Society of Farm Managers and Rural Appraisers."

A.S.A.E. Meetings Calendar

June 17-20, 1940—Annual Meeting, State College, Pa.

August 27-30—North Atlantic Section, Orono, Me.

December 2-6, 1940—Fall Meeting, Chicago, Ill.

Farm Tire Sizes Simplified

FOR several months a committee, representing the farm tractor and implement industry and the tire industry, has been working toward the simplification of farm tire sizes. The first phase of work of the Agricultural Tire Simplification Committee has been completed successfully by the reduction from 214 to 128 in the number of farm tractor tire sizes required by tractor manufacturers, and from 118 to 73 in the number of tire sizes required by implement manufacturers. (W. L. Finger, chairman, tire manufacturers division, Rubber Manufacturers Association, is chairman of the Agricultural Tire Simplification Committee, succeeding W. C. Farlane, who served as temporary chairman at the opening meeting.)

An official list, which shows the sizes approved by the joint committee representing the two industries and the number of units sold last year in each size, is being distributed to all tractor, implement, and tire manufacturers with the urgent request that the engineers use this list of approved sizes in designing their tractors and implements and in selecting tire sizes for them. By means of this list the engineers will be able to pick those sizes which are already in production and to use, if possible, the items that are produced in greatest volume.

The Committee will continue to meet periodically for the twofold purpose for which it was established, namely, (1) to eliminate other existing sizes as the need for them disappears, and (2) to discourage the introduction of unnecessary new sizes which are not required by bonafide engineering considerations or other reasons. The Committee has repeatedly emphasized, however, that it will not take any steps that may retard experimentation, research, or progress in the adaptation of rubber tires to farm machinery, because it is recognized that this movement is still in its early stages and that further development can improve and perfect it.

There was urgent need for work of this nature, for the very rapidity of the growth in the use of rubber tires caused the number of sizes to become uneconomically large. The use of an unnecessarily large number of sizes adds appreciably to the cost of the manufacture of tires, in mold depreciation, curing expense, machine changes, die costs; it increases the manufacturing problems of the farm tractor and implement makers and adds to the inventory burden of both implement manufacturers and dealers. Most important, perhaps, it causes inconvenience to the farmers by hampering interchangeability of wheels, by increasing obsolescence, and by making it more difficult to obtain readily the exact sizes needed for replacement.

Special National Defense Session

PRESIDENT KARL J. T. EKBLAW will call a special session during the annual meeting of the American Society of Agricultural Engineers, to discuss ways and means by which agricultural engineers and the Society can give maximum assistance to the current program of increasing national defense. Exact time of this session has not yet been determined. It will probably be announced during the first day of the meeting.

Personals

Earl L. Arnold, while at Cornell, made a study of "Farm Refrigerated Storages" which is now reported in Bulletin 724 of the Cornell University Agricultural Experiment Station.

Henry J. Barre was the man behind the project and pen which produced "The Relation of Wall Construction to Moisture Accumulation in Fill-Type Insulation," in publication as Research Bulletin 271 of the Iowa Agricultural Experiment Station.

F. C. Fenton and *D. E. Wiant* report on "Rural Electrification Surveys of Harvey and Dickinson Counties" in Kansas State College Bulletin No. 39.

L. W. Hurlbut gives brief information on "Adjusting Corn Planters and Listers for Sorghums," in Circular 64 of the Nebraska Agricultural Experiment Station.

H. F. McColly is author of "The Ice Well Refrigerator," Circular 65 of North Dakota Agricultural Experiment Station.

Howard R. Murphy has been appointed sales manager of the central division, Caterpillar Tractor Company, and will be located at Peoria, Illinois. He originally joined the Caterpillar organization thirteen years ago, where he was employed in various sales capacities, finally that of manager of the company's sales development division. In 1938 he left to join Sears, Roebuck & Company as manager of the tractor department.

C. P. Wagner has compiled a handbook of "Feed Grinding on the Farm," which has been mimeographed for distribution by the North Central Associated Electrical Industries.

Necrology

GEORGE A DECHANT, research engineer of the Oliver Farm Equipment Company, passed away April 15, 1940, on the eve of his 60th birthday. Mr. Dechant was born at Brookfield, Wis., spent his youth on a farm, and graduated from Marquette University. He started his employment in the farm equipment industry with the J. I. Case Co., as salesman and expert. From this beginning he worked up to the positions of branch manager and advertising manager. In 1931 he joined the Oliver organization as factory sales manager, and later was transferred to work as research engineer. He had a wide circle of friends in the industry and among farmers and others with whom he came in contact.

(News continued on page 238)

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the May issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

David S. Betcone, midwestern representative, Douglas Fir Plywood Association, 1904 Daily News Bldg., Chicago, Ill.

Clint W. Bracher, R.R. No. 2, Box 152, Port Lavaca, Tex.

Owen K. Brown, Lindley Hall, Moscow, Ida.

Kermit R. Cline, Fishersville, Va.

J. E. Collins, R.R. No. 1, Box 129, Blacksburg, Va.

Santiago R. Cruz, graduate student, Cornell University, Ithaca, N. Y. (Mail) 315 Eddy St.

Loren J. Dilsaver, 1614 Fairchild, Manhattan, Kans.

R. T. Dottery, Jr., 1428 Prince Ave., Athens, Ga.

Arnold A. Dudley, R.R. No. 1, Cambria, Va.

Raymond C. Fischer, Waterloo, Wis.

Stanley B. George, Beaver House, State College, Pa.

R. L. Givens, Virginia Polytechnic Institute, Blacksburg, Va. (Mail) Box 993.

D. Mark Huber, agricultural representative, Caterpillar Tractor Co. (Mail) R.R. No. 1, Willow St., Lancaster Co., Pa.

Curtis A. Johnson, 630 N. 30th St., Lincoln, Nebr.

Robert H. Joyce, salesman, Joyce Motor Co., Ulysses, Kans.

Lloyd W. Kelly, Box 270, Denton, Tex.

James G. Lassetter, Villa Rica, Ga.

W. H. Latham, chief mechanic, G. L. F. Petroleum Distribution. (Mail) 190 Wildwood Dr., Rochester, N. Y.

Charles T. Male, Jr., graduate assistant, Cornell University, Ithaca, N. Y. (Mail) 317 Dryden Rd.

E. C. Meyer, assistant professor, agricultural engineering department, University of Maine, Orono, Maine.

D. L. Mills, Marye, Va.

Nolan Mitchell, junior agricultural engineer, Tennessee Valley Authority, Knoxville, Tenn.

Howard E. Morrison, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Fort Sumner, N. M.

Vernon G. Moss, supervisor, National Youth Administration. (Mail) Farm Bureau Office, Greenfield, Iowa.

G. H. Norman, Jr., Chatham, Va.

Stanley J. Otis, junior engineer, Rural Electrification Administration, Washington, D. C. (Mail) 5711 16th St., N.W.

Morris W. Pettit, Box 5333, College Station, Tex.

H. B. Pfost, engineering trainee, Rural Electrification Administration. (Mail) 719 Hitt St., Columbia, Mo.

Albert E. Porter, junior agricultural engineer, U. S. Department of Agriculture, Soil Conservation Service. (Mail) Sentinel, Okla.

Merton A. Rietzke, 1321 Laramie St., Manhattan, Kans.

James B. Robinson, Jr., 1203 Linden Pl., North Side, Pittsburgh, Pa.

T. Foster Rose, Stony Creek, Va.

James R. Sausser, Jr., Beaver House, State College, Pa.

Arnold Tandberg, Pekin, N. D.

Arthur H. Thompson, laboratory assistant, Kansas State College, Manhattan, Kans. (Mail) 1404 Fairchild.

H. B. Wall, Jr., trainee, Goodyear Tire & Rubber Co. (Mail) Jackson, Mich.

Lewis D. Worley, area engineer, U. S. Department of Agriculture, Soil Conservation Service. (Mail) Box 610, Jackson, Miss.

Student Branch News

TEXAS

ON April 26 our Branch held its annual barnyard dance. We cleared nearly $400.00, which is about $100.00 more than we made last year. Our plans now are to have at least five boys attend the annual meeting of the A.S.A.E. this summer. The senior agricultural engineering students have used part of the money to a good advantage on inspection trips to Temple and Houston, Texas, to study projects relating to agricultural engineering.—*Clint W. Bracher, Sec'y-Treas.*

OHIO

"AGRICULTURAL Engineering Graduates, 1940-41" is the title of a mimeograph published by the Student Branch of ASAE at Ohio State University. It gives personal data, information on training, kind of work preferred, and a photograph on one page devoted to each individual member of the graduating class of eight seniors. Brief information on the field of agricultural engineering, the instruction offered at Ohio State University, and the activities of the Student Branch are also included.

TENNESSEE

A MULE dynamometer and a mower repair demonstration were two outstanding exhibits which the Branch put on at the East Tennessee Farmers' Convention, May 14 and 15, in Knoxville.

The dynamometer was planned by the senior agricultural engineering students, Nolan Mitchell, Bradford Elliott, and Lymen Roberts, under the supervision of M. A. Sharp. This instrument was made out of the rear end of an old car and cost about $15. The beginning pull is rather light, but it gradually increases until the mule has reached his maximum strength. A big dial was set up on the instrument so that the farmers standing at a distance could tell how much the mule was pulling.

In the mower repair demonstration the mower selected was out of date and practically worn out. The repair demonstration was put on by Branch members under the supervision of Earle K. Rambo.

Other exhibits which the Branch sponsored at the convention were farm water systems in operation, a hydraulic ram, a miniature trench silo, an electric fence, farm gates, and erosion control pictures. The Branch had on display four shallow and deep-well pumps equipped with five dials, one to tell the number of gallons pumped, the second to give the amount of current being used, the third to show the lift of the water in feet, the fourth to show the amount of pressure in the pipe line, and the fifth to show the pressure in the tank.

The Agricultural College is about a mile from the main campus of the University of Tennessee. The Branch operated a tractor and trailer passenger service from the main campus to the Agricultural College so all the students had an opportunity to see this convention.

Throughout the convention agricultural engineering students were near the exhibits to answer questions asked by visitors.

Members of the Branch made a map of the main campus of the Agricultural College and made a number of blueprints of it for the secretary of the East Tennessee Farmers' Convention, as a help to him in determining space allotments for commercial exhibits.—*Marcellus Harris, chairman, publicity committee.*

SASKATCHEWAN

THIS year the Branch president followed the policy of encouraging students to be the speakers at the meetings. Profs E. A. Hardy and R. P. Frey opened their homes to us for our evening meetings.

For the first meeting the speakers were four of the students who made the trip to the A.S.A.E. annual meeting at St. Paul last year. Other meetings at which students were speakers included the one for the machinery seminar and several at which reports were made by students who had been engaged in agricultural engineering activities during the past year, especially at the experiment stations.

Guest speakers included, F. Rowall of the Goodyear Tire and Rubber Co., N. Grierson of the Caterpillar Tractor Company, and J. Macgregor-Smith and G. L. Shanks, from the agricultural engineering departments of the Universities of Alberta and Manitoba, respectively. The remainder of the Branch activities were taken up by our participation in the Engineering Open Night.

Every two years, the Engineering Society of the University of Saskatchewan sponsors an "open night" or demonstration of all the work and activities carried out by its members. Each branch is in charge of a portion of the display, and the A.S.A.E. Student Branch is affiliated with the main Engineering Society at this University.

A large amount of the advertising for the whole show this year was done by members of our Branch and we staged a tractor parade in the downtown section of Saskatoon on the Saturday before the show, using banners mounted on the tractors.

We had exhibits from each separate part of our own department arranged for and displayed by the students.

The show ran for two nights and a total of about 3000 people passed through the engineering building to inspect the various departments. Our Branch only makes up a small part of the Engineering Society, yet our display was comparable to that exhibited by any of the other divisions of the College.

We held our final meeting of the term on April 2, with the following elected as our new slate of officers: Evan A. Hardy, honorary president; R. P. Frey, faculty advisor; D. L. Trapp, president; Pat Ormiston, vice-president; J. Paterson, secretary-treasurer; and A. A. McKinnon and R. B. Hart advisory committee.—*H. Thompson, secretary-treasurer.*

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers thereof, whose names and addresses may be obtained on request to AGRICULTURAL ENGINEERING, St. Joseph, Michigan

THE USE OF ARTIFICIAL LIGHTS FOR TURKEYS, *H. L. Wilcke.* (Iowa Expt. Sta.) Poultry Sci. 18 (1939), No. 3, pp. 236-243, figs. 3. Experiments extending over four seasons gave evidence that turkey females may be brought into earlier egg production by the use of artificial lights either in the morning and evening or all night. It required approximately 6 weeks for turkeys to reach a reasonably high level of production after the lights were turned on. The total number of eggs per bird to the end of June was increased by artificial lighting, while egg weight was not affected. Neither lighting nor heating had any significant influence on fertility or hatchability of the eggs. Total feed consumption was not affected by the use of either heat or light, but heating resulted in a much higher consumption of mash in proportion to grain as compared with the unheated groups.

A SIMPLIFIED TECHNIC FOR THE DETERMINATION OF CONTACT ANGLES AND ITS APPLICATION TO STUDIES ON WETTING, *E. Kneen and W. W. Benton.* (Minn. Expt. Sta.) Jour. Phys. Chem. 41 (1937), No. 9, pp. 1195-1203, figs. 2. The apparatus consisted essentially of an arc lamp, a condensing lens system, an adjustable stage, and either a picture frame holding a thin sheet of paper or a ground glass. The plane surface being studied was mounted on the adjustable stage and brought into the focus of the condensing lens. The liquid to be tested was then placed on the plane surface, and its image was thus projected onto the screen. Contact angles of a variety of substances were tested and found to agree satisfactorily with the published data.

For a series of sodium salts of the fatty acids the contact angle against paraffin was found to change only slightly up to sodium caprylate. Here the contact angle was approximately 110 deg, water 115 deg. From sodium caprylate to sodium palmitate the change in contact angle was pronounced, was essentially linear, and approximated 0 deg at sodium palmitate. Stearic acid and cholesterol both could be obtained with "polar" and "nonpolar" surfaces.

The method is applicable to the study of the wetting capacity of leaf surfaces and of tooth surfaces and offers promise of yielding valuable information on wetting by water, insecticides, or cleansing agents.

FURTHER STUDIES OF SELECTED TYPES OF DOMESTIC GAS STOVES, *A. E. Baragar.* Nebraska Sta. Res. Bul. 111 (1939), pp. 24, figs. 15. The investigation previously noted has been extended to similar studies of six gas ranges, all with small round surface burners and all but one with the enclosed type of top with either removable or fixed burner bowls. Special attention has been paid to causes of the production of excessive carbon monoxide gas by the top burners, more data have been obtained on cooking top efficiencies, and automatic lighters have been studied further. The most extensive work reported, however, was on oven tests, including checks on thermostat calibration, temperature distribution, and heat losses. A special apparatus was devised for measuring vent losses and is described and illustrated.

The significant results obtained in the investigation as a whole have been expressed in the form of a list of optimum requirements of cooking tops and ovens for gas ranges to insure satisfactory performance for economical operation. This list constitutes a set of specifications of value to the prospective purchasers of a gas range whether it be for natural, manufactured, or bottled gas.

PERFORMANCE ANALYSIS OF SELECTED TYPES OF KEROSENE STOVES, *M. M. Monroe.* Maine Sta. Bul. 394 (1939), pp. 433-521, figs. 24. This report of an extensive investigation of the performance of kerosene stoves of different types has been prepared to be of service to other investigators on cook stoves, teachers of household equipment, extension service workers, manufacturers of kerosene stoves, and others particularly interested in the principles of heat transfer for cooking. The first section of the bulletin contains material of a general nature on the principles involved in surface burner and oven cooking with ranges of temperature required, and the various types of kerosene stoves and the principles on which their operation depends. The procedures and results of the present investigation are then discussed in considerable detail for surface and oven cooking, with tables and charts reporting the original data. This technical section is followed by an appraisal of the performance and construction of the stoves tested in which standards for appraising oven and surface burner performance are given in the form of questions and answers for the types of stoves tested. The summary is divided into three parts. The first includes the practical applications of the study which are of interest to the housewife, the second consists of suggestions to manufacturers for improvements in the construction of kerosene stoves, and the third lists for the benefit of other investigators certain precautions to be taken in controlling the testing conditions.

BUYING AND USING KEROSENE STOVES, *M. M. Monroe and E. M. Cobb.* Maine Agr. Col. Ext. Bul. 251 (1938), pp. 23, figs. 6. This nontechnical bulletin has been prepared, chiefly from information obtained in the investigation noted above, to acquaint the housewife with some of the characteristics of kerosene stoves of the three general types of long-chimney wick burners, short-chimney wick burners, and short-chimney wickless burners. The question and answer method of presenting the information is used throughout the text, prefaced by brief statements as to the performance which can be obtained from some kerosene stoves and the details of construction which add to the durability of the stove.

SUPPLEMENTAL IRRIGATION IN MISSOURI, *R. P. Beasley.* Missouri Sta. Bul. 410 (1939), pp. 15, fig. 1. Irrigation in Missouri has thus far been limited, for the most part, to drought years, overhead spray having been most used by truck gardeners, although portable rotary sprinklers have been gaining popularity. The portable rotary sprinkler calls for much less initial outlay but requires more labor in use. A surface irrigation system involves much less initial cost than either type of spray equipment, but it demands more water, distributes it less evenly, is unsatisfactory on sloping land, and has a greater soil-packing tendency than spray systems. Surface irrigation is considered especially adapted to sandy loam soils bordering streams, however. Cultivating the heavier soils as soon as possible after surface irrigation was found largely to counteract their packing tendency and to improve aeration.

Most vegetable and truck growers interviewed believed irrigation had proven a definite asset, enabling them to market their crops earlier, to keep them growing throughout the growing season, and to produce a crop of superior quality. Most of the farmers who had irrigated corn thought the practice profitable in dry years, if not too costly. Certain of these farmers felt that irrigation of corn would be profitable in any season, if not too expensive.

In corn irrigation, the crop may be seriously damaged before water is applied. Preparation for irrigation should be made soon after the corn comes up.

ECONOMIC IMPLICATIONS OF SOIL CONSERVATION IN MARSHALL COUNTY, *E. C. Weitzell.* West Virginia Sta. Bul. 293 (1939), pp. 47, figs. 9. This report is designed to point out economic implications of changes resulting from the planned and managed program of soil and moisture conservation in areas specified and the tendencies toward such changes. To measure the progress of the soil and water conservation program and its effect on the agriculture of the area, farm practice and income records were obtained for farms in the area for the year 1935, before the program was established; the survey was repeated for the year 1937; and three additional annual resurveys are to be made. Some of the principal topics of the present report are description of area, economic evaluation of types and organization of farming in relation to soil conservation, certain factors directly affecting farm profits, and the recommended program of soil conservation.

SOIL DEFENSE OF RANGE AND FARM LANDS IN THE SOUTHWEST, *E. M. Rowalt.* U. S. Dept. Agr., Misc. Pub. 338 (1939), pp. [IV] + 51, figs. 23. This is a more or less popular account of the erosion problems and proposed control and preventive measures in a region including Arizona and New Mexico with parts of Utah and western Colorado. *(Continued on page 242)*

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(Continued from page 240)

A STUDY OF HYDROLYTIC ENZYMES IN ACTIVATED SLUDGE, *R. S. Ingols*. New Jersey Stas. Bul. 669 (1939), pp. 32, figs, 4. There was found to be a marked increase in pepsin during the development of activated sludge from sewage. Lipase, diastase, and trypsin increase slightly. Lipase, pepsin, and diastase were found only on the surface of the sludge floc, but trypsin was found also in the liquor surrounding the floc. The enzyme activities of a mixture of activated sludge and sewage changed little during a 6-hr aeration period. Slight fluctuations in pH had little effect upon the enzymes studied. When activated sludge was aerated continuously for several weeks, the enzymes increased during the first 3 days, then decreased gradually. The diastase of the sludge organisms could be increased 500 per cent by feeding the sludge organisms starch at 5C. The diastase reacted better at a concentration of salts slightly higher than that found in the activated sludge liquors studied. Plasmolysis of the sludge organisms led to an increase in the free enzymes. Clarification of the sewage was found to be correlated with the biophysical properties of the activated sludge floc; purification with the enzyme activity.

ECONOMICAL POWER SPRAYER, *T. E. Ashley*. Miss. Farm Res. [Mississippi Sta.] 2 (1939), No. 9, p. 7, fig. 1. The author describes a barrel sprayer operated by an ordinary well-pump jack having a 16 : 1 ratio, the power being provided by a 0.5-hp gasoline engine capable of operating for 10 hr on 0.5 gal of gasoline and using 1 pt of oil in from 20 to 30 hr of operation. An extra air chamber, found to be necessary for the maintenance of an even and constant pressure of 125 lb, was provided in the form of a 2-ft length of 6-in pipe, capped at each end, fitted with the necessary connections, and attached to the inside of the head of the barrel. A relief valve was added to the pump. The total cost, of which an itemized account is given, was found to be from $60 to $65, exclusive of labor. A sketch shows the general construction, motor, pump, and barrel being mounted on skids. The device is intended to be loaded on a truck or wagon.

PREVENTION AND CONTROL OF GULLIES, *H. G. Jepson*. U. S. Dept. Agr., Farmers' Bul. 1813 (1939), pp. II + 60, figs. 41. The measures mainly emphasized in this publication are those designed to prevent the beginning of gully erosion, rather than the devices for the control and cure of damage already started. It is noted that prevention will require proper land use, conservational farm practices on areas that contribute runoff to the gullies, retention and diversion of runoff water, conveying of water without further damage through any gullies already existing, the use of vegetation in the prevention of gully erosion and in the restoration of preexisting gullies, etc. Measures for the restoration of damaged land, as well as preventive measures, are taken up, however. Natural and planted revegetation are considered; such structures as temporary check dams, permanent soil-saving dams, flumes, and culvert drop inlets are dealt with; and means for protecting banks of small streams, including jetties and protective vegetation, cribbing or riprap, and channel straightening, are described. A short final section stresses the necessity for systematic inspection and repair for the maintenance of preventive and control constructions.

WINTER AIR CONDITIONING: FORCED WARM-AIR HEATING, EDITED BY *S. Konzo*. Columbus, Ohio: Natl. Warm Air Heating and Air Conditioning Assoc. [1939], pp. VIII + 532, pl. 1, figs. [192]. This book is based largely upon work in the warm-air heating research residence at the Illinois Engineering Experiment Station. This work, previously noted in Bulletin 266 and in earlier work of this station, is here supplemented with information from various other sources and with comments by the editor.

The contents are the development of the forced-air heating system; comparison of the gravity warm-air heating plant and the forced-air heating plant; winter air conditioning and human comfort; wet and dry-bulb temperatures and relative humidity; comfort chart and effective temperatures; humidification requirements and limitations; humidification and humidity controls; ventilation and infiltration; filtration of air and air filters; room air temperatures—differentials and variations; heat loss calculations for heating; reduction of heat loss from house, and insulation; air volumes, air densities, and register air temperatures; general performance characteristics of a forced-air heating system; the use of dampers in duct systems; bonnets, baffles, and bonnet air temperatures; field tests of automatic control systems; room thermostats, controls, and zone controls; field tests on register performance; registers and grills; register air temperatures and heat loss from ducts; velocity pressure, static pressure, and total pressure; pressure losses and fan ratings; pressure losses of registers, ducts, and fittings; measurement of air velocities; rational approach to design of duct system; individual duct system; trunk duct systems; special modified forms of duct design; selection of furnaces and burners; furnace capacities and efficiencies; and chimneys and draft, together with appendixes A, containing a tentative code for testing and rating oil-fired, fan-furnace combinations; B, containing excerpts from a "technical code for the design and installation of mechanical warm-air heating systems"; and C, consisting of a survey of commercial practice relative to oil-burning furnaces.

COST OF TRACTOR POWER ON NEBRASKA FARMS, *F. Miller, W. L. Ruden, and C. W. Smith*. Nebraska Sta. Bul. 324 (1939), pp. 18, figs. 3. Tractors of less than 10 rated drawbar horsepower were found to show a higher total cost per unit of power than those of higher rating, but the cost per tractor hour was lower for the small tractors because of the low power rating. There was no significant difference in cost per rated drawbar horsepower hour for items except fuel in tractors of from 11 to 30 hp. Overhead costs per rated drawbar horsepower hour were found to vary inversely with the number of hours the tractor is used annually. Total costs per used drawbar horsepower hour increase as the tractor load decreases from its rated capacity. To maintain low cost per unit of useful power the tractor should be kept to work that uses a high percentage of its rated power. To this end the size of equipment may be increased, more than one piece of equipment may be pulled, a higher gear may be used and the job completed at greater speed, or a higher gear may be used and the tractor throttled to the speed required for the work.

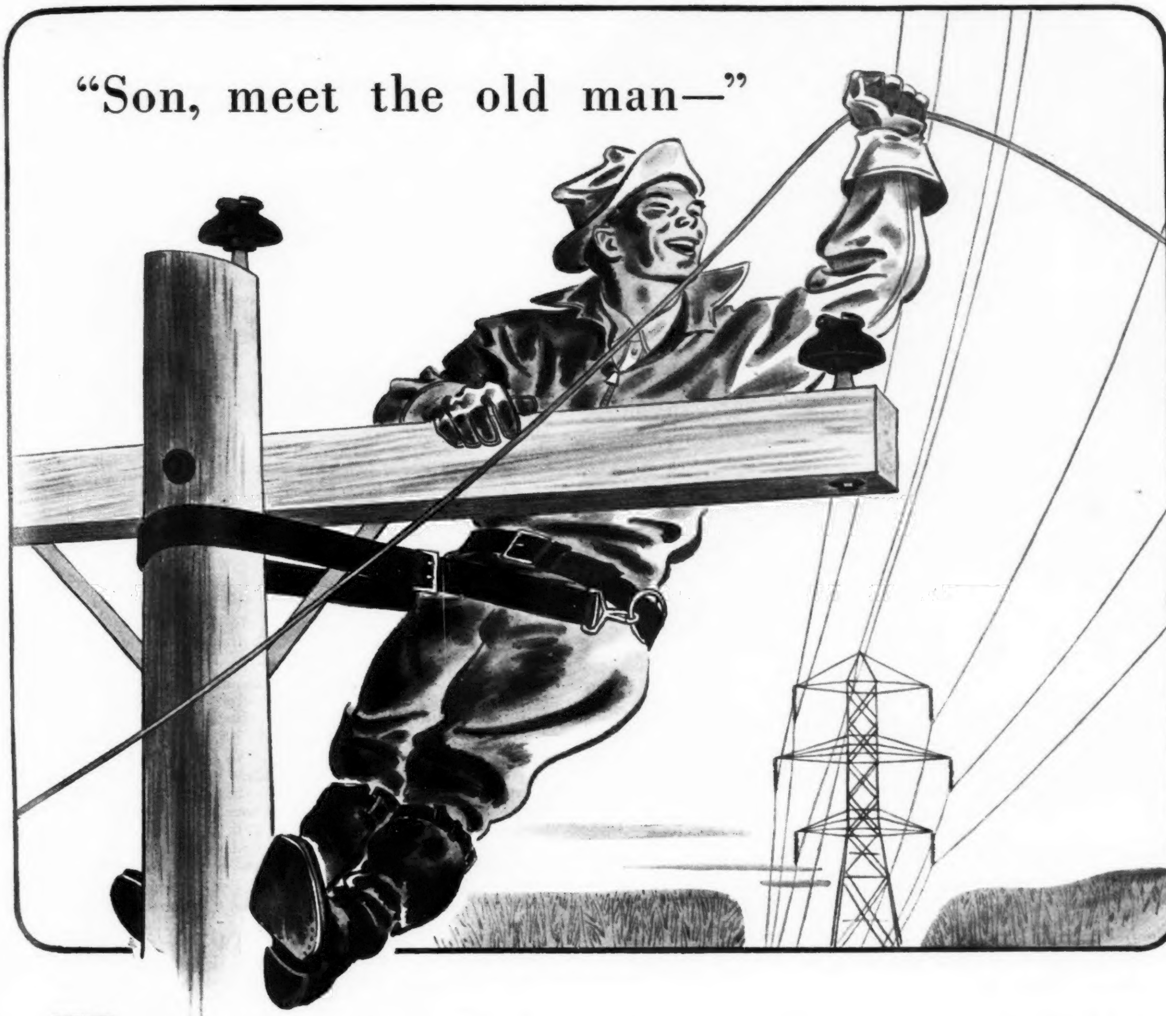
DRYING HAY IN THE BARN AND TESTING ITS FEEDING VALUE, *J. W. Weaver, Jr., and C. E. Wylie*. Tennessee Sta. Bul. 170 (1939), pp. 24, figs. 13. The authors discuss briefly previous devices for drying hay artificially, finding the large commercial types of equipment far too expensive both in initial outlay and in operating costs for any but large-scale operations, while schemes for driving or drawing air through hay stacked in the field, on wagons, or under open shelters are either inefficient when operated with unheated air or too expensive when the air used was electrically heated.

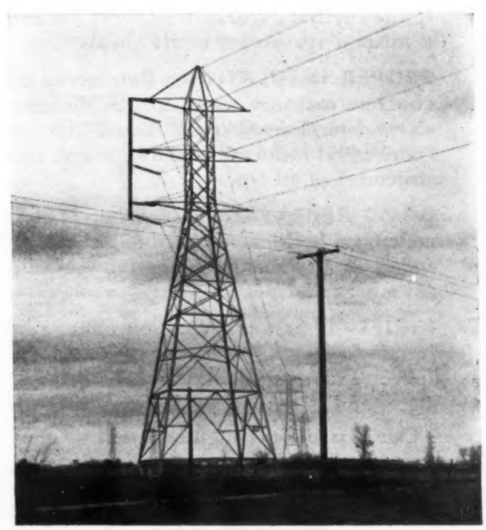
A satisfactory barn-drying system was developed on the basis of the observation that the moisture content of hay falls from about 75 per cent to about 45 per cent in the first 4 to 6 hr of field drying on clear days, a barn drier being then capable of removing approximately 25 per cent more moisture with economically practicable efficiency.

The design here sketched and described provides for a central longitudinal header air duct on the mow floor, ending 5 ft from each end wall, with lateral ducts from 4 to 5 ft apart, open at the bottom and raised 1 in from the floor on 3x1-in strips, the lateral ducts running to a like distance from the side walls. The header duct is, of course, reduced after passing each pair of opposite lateral ducts. For a 30x50-ft mow floor, a blower operated by a 5-hp motor was used. The motor and blower assembly was placed on ground-floor level in a small room attached to the side of the barn. For the 30x50-ft mow floor used, the central header duct was made 16 in wide. The duct system was of wood.

It was found that the air leaving the hay should not carry more than from 70 to 80 per cent relative humidity. When the air flow was reduced so that the escaping air had a humidity of from 90 per cent to saturation, the upper layers of hay remained very damp, and reversing the direction of the flow dried the top layers at the expense of making the bottom layers damp, moldy, and dusty. The most efficient air flow was determined to be 8⅓ cu ft per min per sq ft of mow floor. Barn drying from 45 per cent moisture content to 20 per cent required from 4 days to 2 weeks, according to weather conditions and the quantity of hay stored. From 30 to 40 min of blower operation at about 2 a.m. for three or four nights was provided by means of a timing clock, to counteract a heating tendency observed during the first stage of drying. The most promising method of full automatic control consisted essentially of a thermostat and a humidistat in the motor starter control circuit. Overheating of the hay and blower operation while the atmospheric humidity was too high for effective drying were both prevented by these means. By using air drawn from under a 20x30-ft false roof or sheet metal built over the barn roof on 2x4-in supports, solar heat could be utilized to the extent of raising the air temperature 22 F, with a concomitant lowering of the relative humidity by 33 per cent, at an intake rate of 3,000 cu ft per min.

The barn-dried hay was found one grade and class better than the same hay, field-dried, it showed average contents of 2.3 per cent more leaves and 19 per cent more green color, it had a better palatability and vitamin-A value, and it was dried at an operating cost of about 86 cents per ton. The initial cost of the barn-drying system is stated as from $300 to $500. *(Continued on page [illegible])*


"Son, meet the old man—"



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EFFECT OF WEIGHT OF TAMPERS AND NUMBERS OF TAMPS ON THE FLEXURAL STRENGTH OF CONCRETE SILO STAVES, *C. A. Hughes, D. G. Miller, and P. W. Manson.* (Minn. Expt. Sta., U.S.D.A., et al.) Jour. Amer. Concrete Inst. 11 (1939), No. 1, pp. 37-47, figs. 3. Transverse strength tests were made on 324 out of 502 concrete silo staves to determine, mainly, the effect of number of tamps and weight of tampers. The proportion of cement (as number of staves per bag of cement), the aggregate grade, and the mix consistency were also varied.

Transverse strength increased with increasing weight of the tampers from 50 to 75 lb, the increase varying with the composition of the mix; and with increasing number of tamps up to 6, the strength increased again, varying with the mix when the number of tamps exceeded 6. Staves made with 2 tamps of the heavier tamper were nearly always stronger than those made with 6 tamps with the lighter tamper. With the number of tamps exceeding 6, strength first increased further (an effect attributed to further consolidation), then fell off (a result considered due to a churning effect of excessive tamping), and, with still further tamping, showed further rise and fall of the strength curves.

The three cement contents used were represented by 7, 9, and 11 staves per 94-lb bag of cement. Aggregate gradings finer than the plant grade, the same, and coarser than plant grade were also tested, as were mixes drier and wetter than those of plant practice and mixtures in accord with the plant practice in this respect.

TRACTION TESTS OF SINGLE PNEUMATIC TIRES VERSUS DUAL PNEUMATIC TIRES, *E. C. Sauve.* Michigan Sta. Quart. Bul. 22 (1939), No. 2, pp. 59-71, figs. 8. At the recommended inflations of 12 lb per square inch in 9.00-36 four-ply single and 20 lb per square inch in 5.00-44 four-ply dual tires, giving approximately equal loaded radius in the two sets, traction, as pounds pull on the tractor drawbar, was greater with the single than with the dual tire sets at the same percentage slippage for all soils and conditions tested as follows: In sand 41.1 per cent, disked ground 20.4, freshly plowed ground 19, muck (plowed and rolled) 15, sod 13.25, and muck (mint stubble) 11.7 per cent. At 16 per cent slip, the drawbar pull increase with the single pneumatics for 544 lb added to the traction members was, on sod 400 lb, sand (oat stubble) 280, muck (mint stubble) 250, and freshly plowed ground 280 lb; with the dual pneumatics under like conditions, on sand (oat stubble) 240 lb and muck (mint stubble) 180 lb. The maximum drawbar pull was obtained with an average slippage of 45 per cent. The maximum horsepower was obtained with an average slippage of 23 per cent. The coefficient of traction (ratio of drawbar pull at 45 per cent slippage to the (zero load) weight on drive wheels) was on muck (plowed and rolled) singles 0.38, duals 0.33; muck (mint stubble) singles 0.55, duals 0.50; silty loam (sod) singles 0.90, duals 0.82; silty loam (freshly plowed) singles 0.62, duals 0.54; sand (oat stubble) singles 0.60, duals 0.49; and silty loam (freshly plowed and disked) singles 0.71, duals 0.60. Changing the spacing of the duals from 9 in center to center, to 7 in did not appear to affect traction in one comparison.

FARM REFRIGERATED STORAGES, *E. L. Arnold.* [New York] Cornell Sta. Bul. 724 (1939), pp. 40, figs. 12. This bulletin reports a study of locations of farm storage plants, structural details including type of building, insulation, type and size of mechanical equipment, produce stored, and owners' opinions with respect to the value of the storage facilities used. The survey covered 138 storage buildings, of which 87 were refrigerated, in Massachusetts, Connecticut, New York, Pennsylvania, and New Jersey, and in the Province of Ontario, Canada.

Of 87 refrigerated storage plants, 80 were used for apples, as were also 40 out of 51 nonrefrigerated storage spaces. Equipment capable of keeping apples until April could be built and operated at a cost of about 16 cents per stored bushel, whereas the average New York City price during 21 yr has been 56 cents per bushel more in April than in October.

The storage room is considered to be best made approximately square, with as high a ceiling as will permit convenient loading; machine room, packing room, and box, crate, and barrel space adjacent. A connected salesroom was found also of value. Types of wall and ceiling construction, insulation, cooling units, source of power, refrigerants, comparative merits of blower and coil cooler systems, etc., are discussed in general terms, and tabulated data concerning storage temperatures, climatic factors, properties of building and insulating materials, and refrigerants are given, but without specific constructional designs or drawings. Among other information brought out in the survey was the fact that 57 per cent of the refrigerated storage buildings had blower systems as against 43 per cent using coil systems. A very brief appendix deals with the measurement of heat and of refrigeration and the terms expressing such measurements. *(Continued on page 246)*

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TRACTOR COSTS IN MICHIGAN, 1938, *F. M. Atchley.* Michigan Sta. Quart. Bul. 22 (1939), No. 2, pp. 91-96. The cost data here tabulated and discussed were obtained with the cooperation of 45 farmers operating 46 tractors. Expenses of operating and maintaining one-plow, two-plow, and three-plow tractors were separately determined. Data concerning type of fuel used (gasoline, distillate, or kerosene) were obtained, together with consumption figures. Percentage of total working time in various uses was also recorded for the three types of tractor, and other subjects considered were size of tractor in relation to labor and power costs, hours tractor use and tractor costs, and influence of size of farm.

COLLOIDS IN SEWAGE AND SEWAGE TREATMENT. I, OCCURRENCE AND ROLE—A CRITICAL REVIEW, *W. Rudolfs and H. W. Gehm.* (N. J. Expt. Stas.) Sewage Works Jour. 11 (1939), No. 5, pp. 727-737. A critical review indicates that various methods of measurements produce widely varying results. The sewage solids are classified as settleable, dispersed, pseudo and true colloidal sols, and soluble solids. The true colloidal sols probably amount to less than 10 per cent of the total suspended solids. The proportions of colloids in fresh solids are relatively low, increase during digestion, and decrease as digestion approaches completion. The colloids appear more important in sludge dewatering than dissolved amino and ammonia nitrogen. Bacterial jellies are most important in aerobic processes and streams.

MODEL EXPERIMENTS ON TILLAGE TOOLS, *K. J. DeJuhasz and A. W. Clyde.* (Pa. Expt. Sta.) Instruments, 12 (1939), No. 5, p. 144, fig. 1; abs. in Pennsylvania Sta. Bul. 382 (1939), p. 19. The authors present a tentative outline for the construction of a model testing trough (to be made from 40 to 50 ft long, from 3 to 4 ft wide, and about 1 ft deep) for studies of reaction of the soil upon the tool; variation of reaction with speed, depth of cut, composition and condition of the soil, and orientation of the tool; best hitching arrangement; constructional design data; and relative tillage efficiency of tools and effects of variations in setting. The essential mechanism is to consist of a reference frame moved accurately along the trough on wheels or skids by a motor and rope drum or by a hydraulic cylinder and pulley system, and provided with recording instruments, motion-picture equipment for recording soil motion, and an observer's seat; together with a subframe carrying the tool and arranged for slight displacement, with respect to the reference frame, in 6 deg of freedom with measurement of the corresponding force components acting on the tool.

The probability of a scale effect, due to the fact that the size of the soil particles cannot be reduced with the size of the tillage tool, and the possibility of difficulty in getting the soil in the trough into a condition sufficiently similar to that of soil under natural conditions are recognized, but it is believed that the method indicated may be a valuable supplement to work with full-size tillage tools in the field, and such indoor testing will be free from some obvious limitations of the field work.

Literature Received

RURAL ELECTRIFICATION LESSONS FOR BOYS' GROUPS, by D. E. Washburn. Paper-bound, 70 pages, 8½x11 in. 65 illustrations. Fifteen lessons covering splicing-soldering-taping, a study of wiring materials and workmanship, how to read your electric meter, planning a wiring job and estimating materials, how to install a convenience outlet, installation of single-pole wall switches, three-way switches, service entrance installations, building a home-made yard light, a study of outside wiring, building a home-made electric brooder, constructing an electric hotbed, making a motor portable, laboratory use of ammeter and volt meter, and voltage drop and how to use voltage-drop tables. Agricultural engineering development division, commerce department, Tennessee Valley Authority, Knoxville. No price stated.

NATURAL AND ARTIFICIAL DRYING OF HAY, by J. W. Weaver, Jr., and George E. Zerfoss. Mimeographed, paper-bound, 43 pages, 8½x11 in. A bibliography of 533 selected references on the subject, arranged alphabetically by authors and indexed by subject matter, including crops, animals, properties, sciences, equipment, processes, and other angles of interest in hay drying. Agricultural engineering development division, commerce department, Tennessee Valley Authority, Knoxville. No price stated.

(Continued on page 248)

Literature Received

(Continued from page 246)

PUBLIC SPEAKING FOR TECHNICAL MEN, by S. Marion Tucker. Cloth bound, 397 pages, 5½x8 in, indexed. Values and principles of effective speech, presented in a highly readable style and illustrated with narrative of events and typical personalities of an hypothetical technical meeting. The author places a high degree of importance on consideration for the audience as a means of having speech accomplish its objectives. Common weaknesses, and factors in speaking effectively, as covered in this book, are indicated in some measure by the chapter headings. These are (1) the story of a day's speaking at the convention, (2) scientist and technologist as speakers, (3) our principal faults as speakers, (4) the chief by-product: personality and personal power, (5) nervousness before an audience, (6) reasons for studying the audience, (7) fundamental facts in regard to interest, (8) opening the speech: greetings and compliments, (9) making contact with the audience: practical devices, (10) more devices for making contact, (11) keeping contact with the audience, (12) keeping contact by appeals to self-interest, (13) personality of the speaker: the main factor, (14) platform manners: how the body talks, (15) platform techniques, (16) more platform techniques, (17) the voice of the speaker as an asset or a liability, (18) typical faults in using our voices, (19) conditions in the auditorium as affecting speaker and audience, (20) clearing the way for organization of speech material, (21) organizing the speech: principles of order and how to apply them, (22) acquiring a vocabulary, (23) using words correctly and forcefully, (24) saying things in the right way; effective words and sentences, (25) making our meaning clear: various devices, (26) reasons for watching the audience, (27) speaking over the radio, (28) learning how to speak: a symposium of experiences, (29) the usefulness of mental reserves; liberal reading, (30) Morrison prepares a speech, and (31) Morrison makes his speech. McGraw-Hill Book Co., New York, $3.00.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

MERCHANDISING SPECIALIST (R.E.A.), UTILIZATION REPRESENTATIVE (R.E.A.) CHEMIST, CHEMICAL TECHNOLOGIST (Various grades). The U. S. Civil Service Commission announces unassembled open competitive examinations for the positions indicated above, in its announcement Nos. 40, 41, and 42. Applications for the first two classifications must be on file in Washington by June 17, or June 20 if mailed from western states; and for the chemical classifications, by June 24, or June 27 if mailed from western states. Application form No. 8, copies of which may be obtained from any first-class post office, should be used in filing application for this examination. Other usual Civil Service examination regulations apply.

POSITIONS WANTED

AGRICULTURAL ENGINEER with B.Sc. and M.S. degrees in agricultural engineering from two of the leading land-grant colleges in the South, desires employment with farm implement company, teaching, or agricultural extension work provided there is an opportunity for advancement. Has one year's experience in agricultural extension work and four years of college teaching. Rural background. Age 27. Health excellent. No defects. Married. Now employed. References and complete information furnished upon request. PW-318

AGRICULTURAL ENGINEER desires position in rural department of any firm serving agriculture; or extension, research, or teaching position in a public service institution. Experienced and qualified in all branches of agricultural engineering, with emphasis on structures and land management, including irrigation. Age 27. Married. Complete educational and professional record available upon request. PW-319

AGRICULTURAL ENGINEER with bachelor's degree from Mississippi State College and master's degree from Iowa State College desires teaching, research, or extension work. Three years teaching experience at Texas A. & M. College. Age 25. Married. PW-320